AGRICULTURAL ECONOMICS RESEARCH

JULY 1973 • VOL. 25, NO. 3

In this issue *Page*

U.S. DEPARTMENT OF AGRICULTURE • Economic Research Service

CONTRIBUTORS

THOMAS A. CARLIN is an agricultural economist with the National Economic Analysis Division, ERS.

DALE HEIEN, econometrician, JIM MATTHEWS, agricultural economist, and ABNER WOMACK, mathematical statistician, are with the National Economic Analysis Division, ERS.

JITENDAR S. MANN is an agricultural economist with the National Economic Analysis Division, ERS.

JAMES P. CAVIN, formerly Director, Economic and Statistical Analysis Division, ERS, now lives in Gaithersburg, Md.

DAVID DYER is an economist in the Sector Performance Measures program area, National Economic Analysis Division, ERS.

JACK BEN-RUBIN, formerly in the Economic Development Division, ERS, is now in the Rural Development Service.

HOWARD A. OSBORN is an economist in the Resource Conservation and Development Group, Natural Resources Economics Division, ERS.

VIVIAN WISER is project leader of the Farm History Research Unit, Agricultural History Group, National Economic Analysis Division, ERS.

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the United States Department of Agriculture and Cooperating Agencies

JULY 1973 • VOL. 25, NO. 3

Economic Position of Farm Families When Money Income and Net Worth Are Combined

By Thomas A. Carlin

Farm families have historically had lower money incomes and a less equal distribution of money income than nonfarm families. However, when net worth was included in a measure of economic well-being for farm families, the median level increased and inequality in the distribution decreased. The distribution of well-being of U.S. farm families in 1966 closely approximated that of all U.S. families when the broader well-being measure was used.

Key words: Farm families, income, wealth, net worth.

Historically, the level of money income of U.S. farm families has been lower and the distribution of income among them less equal than that of nonfarm families (*1*, *2*).[1] Since the late 1950's, the composition of income has changed for farm families. In 1960, about 42 percent of the money income per farm-operator family came from off-farm sources. By 1971 the percentage had increased to 53 percent (*10*). About 60 percent of those persons reporting farm earnings on 1966 Federal income tax returns had an off-farm source of income that exceeded income from farming (*8*, p. 6).

Net worth per farm family averages almost twice that of all U.S. families (*9*, p. 161) because farm families save and reinvest a large proportion of their income in the farm business. Also, farm families have benefited greatly from capital gains on farm real estate. Thus, net worth should be considered along with income when discussing the economic situation of farm families.

Why are both income and net worth important when considering the economic situation of people? Because money income alone understates the true economic situation. Two individuals with low money incomes, one having substantial net worth and the other having little, would be economically dissimilar. Yet, in most income statistics, the two would be considered together. A new concept called "economic well-being," which takes account of both income and wealth, is used in this study. The purpose is to determine the effect of net worth on the level and distribution of economic well-being among farm families.

Data Source

The data used for the study are from the Pesticide and General Farm Survey conducted by the U.S. Department of Agriculture in 1966. This survey provides the most recent readily available information on income and net worth for farm families. Although more recent data would be preferred, the data used are believed to be valid for the purpose of this study.

After the data were edited for missing information, 5,649 observations were retained for analysis. When the observations were distributed by region and economic class of farm, the weights provided in the survey did not satisfactorily represent the population of farms based on the 1964 Census of Agriculture. A weighting scheme was devised to overcome this deficiency and provide improved estimates of farm numbers. Personal distributions of income and well-being were then developed, using individual observations and the weighting scheme.

Income Measures Used

The mean and median are the measures of central tendency used in the analysis. Because income distributions are almost always skewed to the right, the median income is typically less than the arithmetic mean. A few families with large incomes pull the mean above the level of most families. Thus, more emphasis is given to the median in this study.

The Gini ratio is used as the measure of the degree of income inequality. This is the ratio of the area between the diagonal and the Lorenz curve to the total area under the diagonal A/A+B (fig. 1). As ordinarily used, the theoretical value of the Gini ratio ranges from 0 to 1. A ratio near zero means that income was nearly equally distributed among families. A value near 1 means that most of the income is received by a few families.

The index of integration measures the overlap of

Footnotes are at end of article, p. 69.

income distributions. If the distribution for farm families is superimposed on that for nonfarm families, the index of integration measures the area common to the two distributions (fig. 2) (*14*). The larger the index of integration, the greater the degree of overlap.

Assumptions

Each observation in the survey was assumed to represent a family farm. Approximately 96 percent of the businesses reporting farm income for tax purposes in 1966 were sole proprietors (*12*). Although some of the observations may not represent families, it was assumed that such exceptions would not greatly alter the results.

Money income. Money income includes that from both farm and nonfarm sources. Nonfarm income includes wages and salaries, rental income, interest, dividends, retirement pensions, social security, and other transfer payments.

Net worth. The problem of tying income and net worth together is not new in economics. Income is a flow concept while net worth is a stock. Thus, addition is not appropriate. Weisbrod and Hansen (*13*) have suggested a way to convert net worth into a flow which can then be added to money income to obtain a new measure of well-being. Using their model, current net worth is converted to an annuity to yield a lifetime flow. The annuity is then added to current income. Weisbrod and Hansen summarized their model as follows:

$$Y_t^* = Y_t + NW_t \cdot A_n$$

where Y_t^* is the measure of well-being in time period t, Y_t is current money income, NW_t is current net worth, $A_n = r/1-(1+r)^{-n}$ = the factor which converts $1 to an n year annuity at a given rate of interest r, and n is the life expectancy of the family beyond time period t.[2]

The Weisbrod-Hansen model requires information about the family beyond time period t. For this study, each observation was assumed to represent a family with husband and wife present. The expected life of the family, used as the value of n, was based on the life expectancy of the wife, who was assumed to be 2 years younger than her spouse (7).

Money income reported in the Pesticides Survey reflects returns from all resources including capital. To avoid double counting, returns to equity capital were estimated and excluded from current income before applying the annuity principle.[3] A precise calculation of the contribution of capital to current income, particularly for the farm, was virtually impossible. To estimate such returns, a flat amount ($15,000) was deducted from net worth to cover unproductive and unmeasured resources on the farm such as a house. A 4-percent return to capital was then applied to "productive" net worth. This rate reflects average return to farm equity between 1960 and 1969 (*4*).

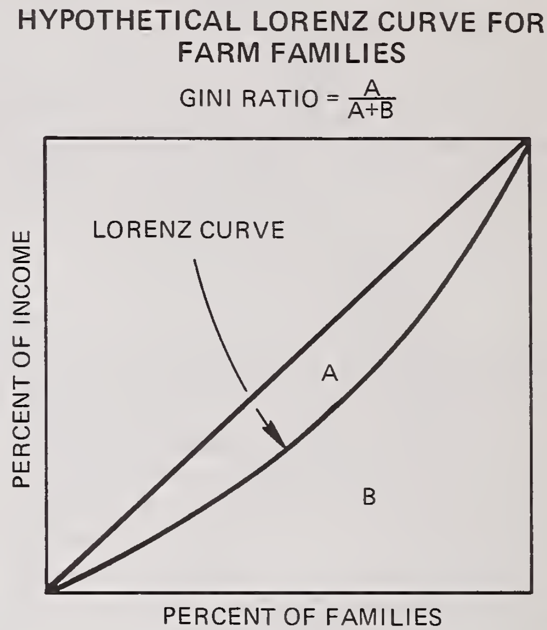

Figure 1

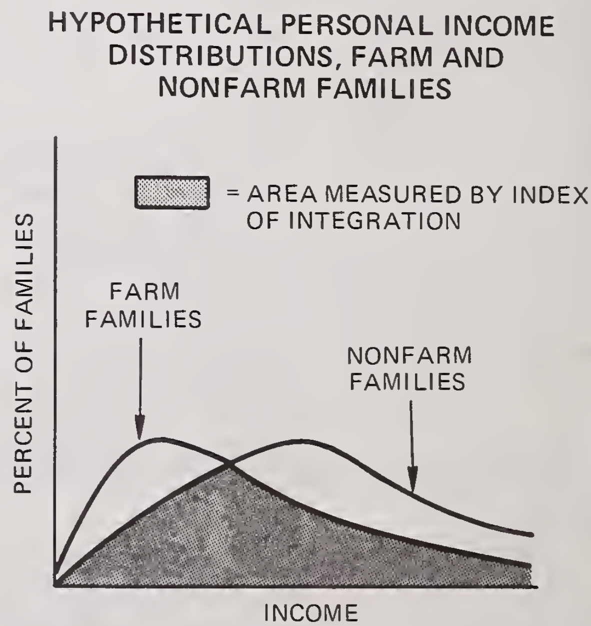

Figure 2

Table 1.—Distribution of farm families, by amount of money income and region, 1966[1]

Region	Number of families	Families earning— Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$14,999	$15,000-$24,999	$25,000 or more	Mean	Median	Gini ratio
	Thou.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Dol.*	*Dol.*	
Northeast	227	26	17	38	15	2	2	6,700	5,900	.436
Appalachian	529	44	25	24	5	1	1	4,000	3,000	.469
Southeast	273	54	19	21	4	2	[2]	3,600	2,300	.553
Delta	252	45	22	25	5	2	1	4,500	3,000	.524
Corn Belt	661	21	29	36	10	3	1	5,900	5,000	.395
Lake States	343	29	32	31	7	1	[2]	4,700	4,000	.398
Northern Plains	271	27	32	33	6	2	[2]	5,000	4,200	.410
Southern Plains	293	26	23	31	11	7	2	6,900	5,200	.467
Mountain	134	24	25	35	11	3	2	6,500	5,000	.595
Pacific	166	17	24	36	15	6	2	6,800	6,100	.516
United States	3,149	32	26	30	8	3	1	5,300	4,200	.475

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.
[2] Less than 0.5 percent.

The analysis was approached in the following way. First, distributions of money income among farm families were developed for the 10 farm production regions[4] and the United States. The stock of wealth (net worth) was converted into a flow and added to income. An annuity rate of 6 percent was used in conjunction with the 4-percent return to equity capital.[5] As a final step, money income and the annuity were combined and the distributions compared with those of all U.S. families.

Results

The distribution of money income for U.S. farm families and the 10 farm production regions serves as the benchmark for the first phase of the analysis (table 1). Based on Gini ratios, money income tends to be more unequal for farm families in the Southeast, Delta, Mountain, and Pacific regions than for all U.S. farm families. Inequality was less in the Corn Belt and Lake States.

Fifty-six percent of U.S. farm families analyzed had money incomes of less than $5,000 in 1966. Low incomes were relatively common in the Southeast, where 73 percent had money incomes of less than $5,000. Of particular interest in this study is the effect on the low-income group of incorporating net worth into a measure of well-being.

Effect of adding net worth. The average net worth of farm families analyzed in this study (table 2) was

Table 2.—Average money income, average net worth, and net worth-income ratio for farm families, by size of money income, 1966[1]

Money income size class	Average money income	Average net worth	Ratio of net worth to income
	Dollars	*Dollars*	
Less than $2,500	1,030	29,990	29.14
$2,500-$4,999	3,650	39,010	10.70
$5,000-$9,999	6,920	47,460	6.87
$10,000-$14,999	11,820	63,790	5.40
$15,000-$24,999	18,140	136,910	7.55
$25,000 or more	43,290	346,340	8.00
All families	5,300	46,630	8.80

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

LORENZ CURVES FOR MONEY INCOME AND WEALTH FOR U.S. FARM FAMILIES, 1966

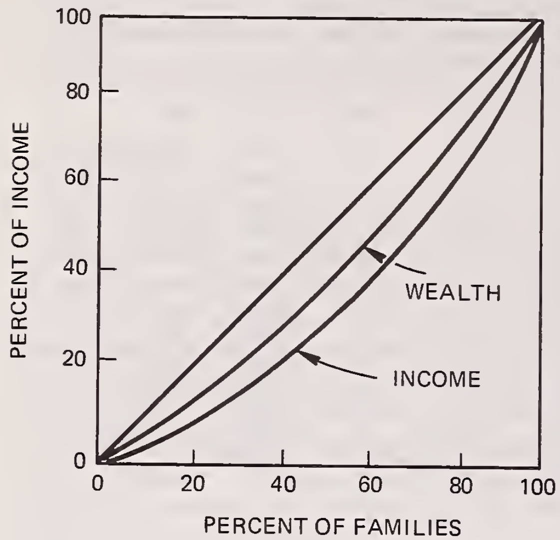

Figure 3

LORENZ CURVES FOR MONEY INCOME AND WELL-BEING FOR U.S. FARM FAMILIES, 1966

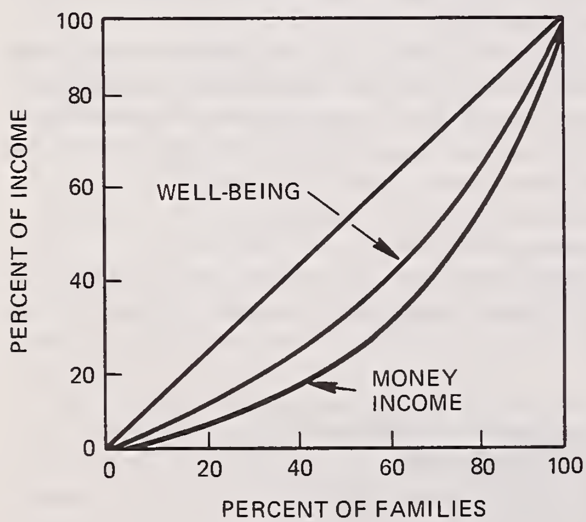

Figure 4

approximately twice that obtained by Projector and Weiss for all U.S. families (*6*).[6] The favorable net worths of farm families may offset their relatively low money income position. For example, one-fifth of the families received only 3 percent of total money income, yet they owned about 12 percent of total net worth of all farm families (fig. 3). Thus the economic well-being of this low-income group is better than money income comparisons alone might suggest.

When net worth was converted into a flow and added to money income, the median well-being measure for U.S. farm families increased by $1,900 (table 3 and 1 and fig. 4). The effect of net worth was substantially different among regions. In the Southeast and Delta regions, where average net worth was relatively low, the median increased about $1,400. However, the median increased $2,500 for the Southern Plains, where average net worth was the highest. Except for the Mountain regions, distribution of money income and net worth among farm families was considerably more equal than the distribution of money income. Although the Mountain region had the second highest net worth, the median increased the least—$1,300. Distribution of net worth among families in the Mountain States is probably less equal than that of families in other regions.

Slightly over 1 million farm families had money income of less than $2,500 in 1966. When net worth was added to money income, 54 percent moved to a higher well-being group (table 4). Thus, only 15 percent of the families had levels of well-being below $2,500, compared with 32 percent with money incomes at this level. Approximately 61 percent of families with money incomes of $2,500 to $4,999 moved to a higher group with the incorporation of net worth.

The results of this study appear to be opposite to those obtained by Weisbrod and Hansen for all U.S. families. Weisbrod and Hansen concluded that the distribution of well-being became less equal with the addition of net worth (*13*, pp. 1320-1321). The result for farm families differs because the net worth-income ratio decreased as money income increased (table 2). For all U.S. families, Weisbrod and Hansen found that the net worth-income ratio increased with the level of money income. The economic position of older farm families contributes considerably to the decreasing net worth-income ratio found in this study. Many of them have low money incomes while, at the same time, they typically have large net worths (table 5).

Comparison with all U.S. families. The analysis was repeated for farm families, using the 4-percent annuity rate. This procedure allowed direct comparison of results for the farm group with those of Weisbrod and Hansen. The distribution of well-being of farm families is almost identical to that of all U.S. families when wealth and nonmoney income are considered (table 6 and figs. 5 and 6). The index of integration, based on money income between farm and all U.S. families, was 0.76 in 1966 (*11*). When wealth was added, the index jumped to 0.91.

Comparison of cross-sectional findings from different years may appear questionable because underlying

Table 3.—Distribution of farm families by amount of money income and annuity, by regions, 1966[1]

(Returns to capital at 4 percent and annuity interest at 6 percent)

Region	Families earning—						Mean	Median	Gini ratio	Average net worth[2]
	Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$14,999	$15,000-$24,999	$25,000 or more				
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Dol.*	*Dol.*		*Dol.*
Northeast	6	22	41	21	7	3	8,800	7,800	.349	45,300
Appalachian	24	31	32	9	3	1	5,700	4,500	.414	29,600
Southeast	37	25	24	9	4	1	5,300	3,700	.499	31,700
Delta	27	28	28	11	4	2	6,300	4,400	.470	32,700
Corn Belt	6	22	47	17	6	2	8,300	7,100	.331	48,700
Lake States	11	29	45	10	4	1	6,600	5,700	.320	37,700
Northern Plains . .	10	25	42	16	6	1	7,700	6,500	.349	55,800
Southern Plains . .	7	19	40	18	11	5	10,000	7,700	.406	68,100
Mountain	12	18	37	20	10	3	11,500	6,300	.586	67,300
Pacific	6	12	48	20	10	4	9,800	8,300	.412	62,500
United States . . .	15	24	39	14	6	2	7,600	6,100	.414	46,600

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.
[2] Unpublished data from Dorwin L. Williams, Economic Research Service.

Table 4.–Distribution of U.S. farm families by money income and by combined money income and annuity, 1966[1]

Money income size class	Distribution by money income	Money income-annuity size class: Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$14,999	$15,000-$24,999	$25,000 or more
	Thou.	*Thou.*	*Thou.*	*Thou.*	*Thou.*	*Thou.*	*Thou.*
Less than $2,500	1,001	460	448	75	12	6	
$2,500-$4,999	806		313	463	26	2	2
$5,000-$9,999	962			685	246	26	5
$10,000-$14,999 . . .	263				171	89	3
$15,000-$24,000 . . .	84					63	21
$25,000 or more	33						33
Total	3,149	460	761	1,223	455	186	64

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

economic conditions may differ. However, there is some evidence that the distribution of net worth for the population as a whole has remained stable—at least between 1953 and 1962 (5).

Older farm families. Because of their usually low incomes and high net worths, older farm families—those whose heads were 65 or over—were analyzed separately. Money income was more unequally distributed among older farm families than for all farm families (tables 7 and 1). In 1966, 60 percent of older farm families had money incomes of less than $2,500. They accounted for 31 percent of all farm families in that income class.

Although the addition of net worth and nonmoney income reduced the degree of inequality of well-being for older families, the effect was not as great for all farm families (tables 7 and 3). However, the increase in median—$3,400—was higher and the reduction in the percentage of families in the lowest income class was greater for older farm families than those for all farm families.

Sixty-eight percent of the older farm families with money incomes of less than $2,500 moved to a higher well-being class when nonmoney income was considered (table 8). Thus, about 32 percent of the families in the under-$2,500 class remained there after net worth was added to money income.[7]

Concluding Remarks

Although the study suggests that there is little difference in total economic well-being between farm and nonfarm families, the underlying components differ between the two groups. Nonfarm families typically have higher money incomes than farm families but lower net worths. Considerable public money is channeled into the

Table 5.–Average income, average net worth, and net worth-income ratio for farm families, by age of family head, 1966[1]

Age of family head	Number of families	Average total income	Average net worth	Ratio of net worth to income
	Thousands	*Dollars*	*Dollars*	
Less than 35 years . . .	335	5,960	31,500	5.28
35-54 years	1,493	6,300	48,280	7.67
55-64 years	807	4,510	46,930	10.40
65 years and over . . .	514	3,210	51,250	15.98
All families	3,149	5,300	46,630	8.80

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

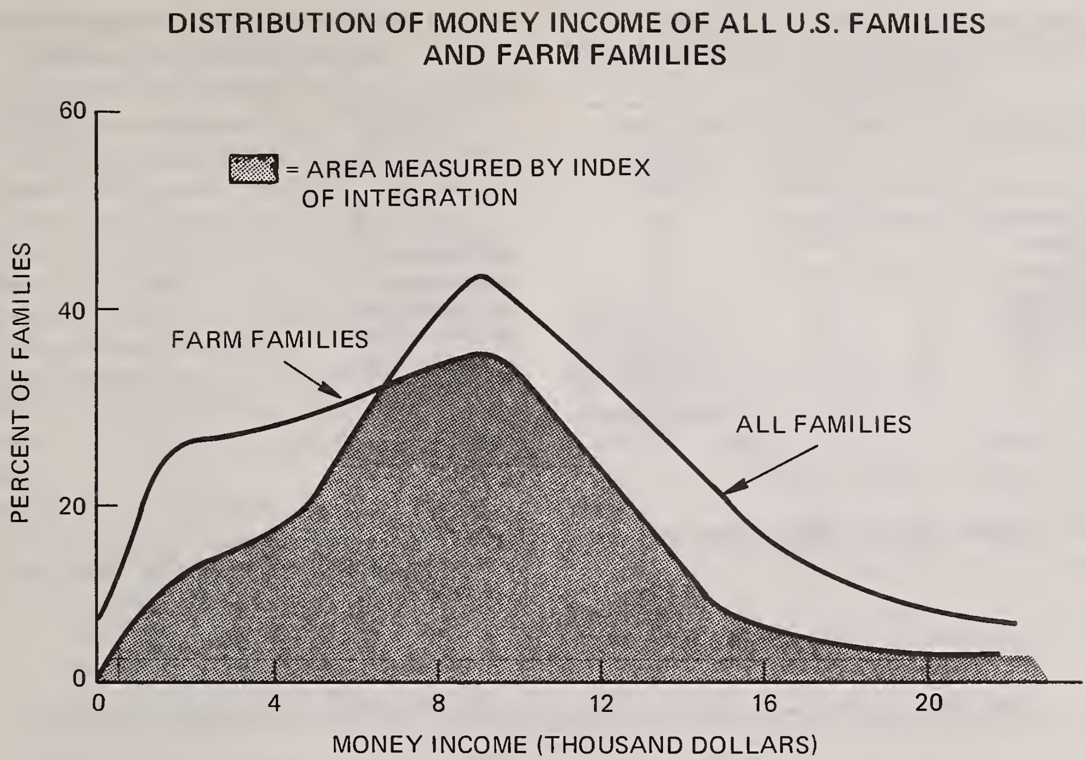

Figure 5

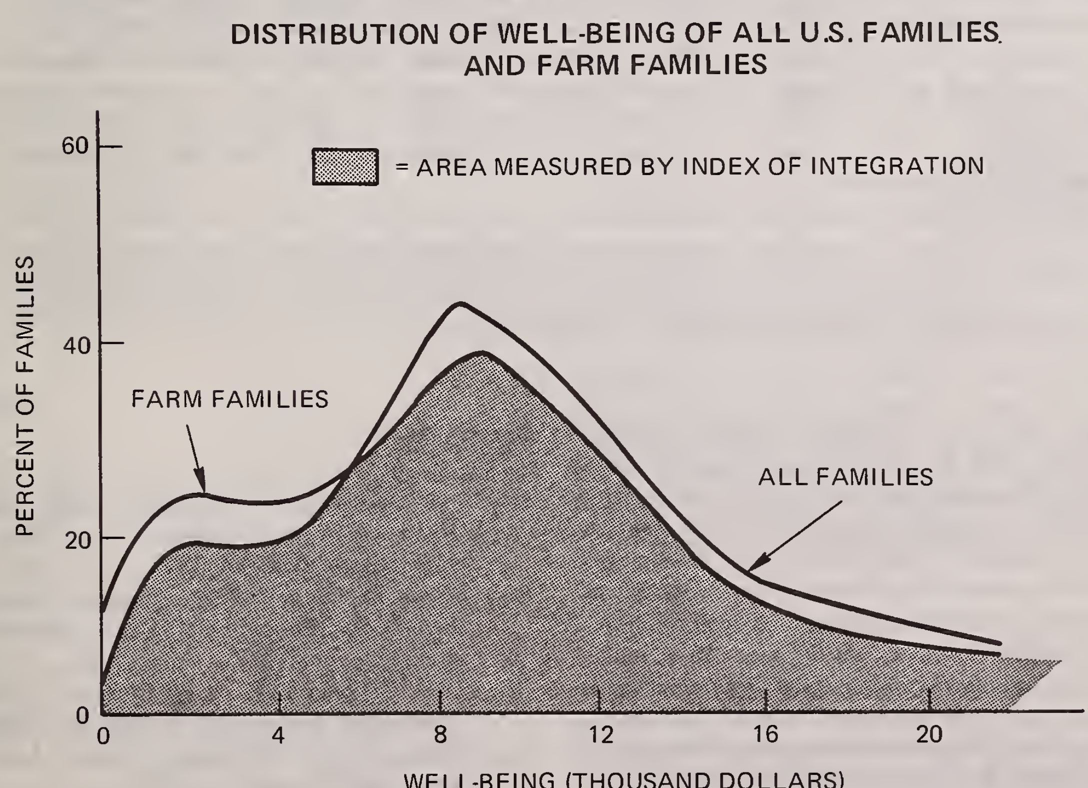

Figure 6

Table 6.—Distribution of well-being for all families in 1962, reported by Weisbrod and Hansen, and for farm families in 1966, 4-percent annuity

Well-being size class	All families[1]	Farm families[2]
	Percent	*Percent*
Less than $3,000	18	23
$3,000-$4,999	17	21
$5,000-$9,999	42	38
$10,000-$14,999	15	13
$15,000-$24,999	6	4
$25,000 and over	2	1
Gini ratio	.42	.41
Index of integration	.91	

[1] Source: (*13*).
[2] Based on tabulations from the 1966 Pesticide and General Farm Survey.

Table 7.—Distribution of older U.S. farm families by alternative concepts of economic well-being, 1966[1]

Money income size class	Money income	Money income and annuity
	Percent	*Percent*
Less than $2,500	60	19
$2,500-$4,999	25	35
$5,000-$9,999	12	29
$10,000-$14,999	1	9
$15,000-$24,999	1	5
$25,000 or more	1	3
	Dollars	*Dollars*
Mean	3,200	7,400
Median	1,600	4,700
Gini ratio	.511	.494

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

Table 8.—Distribution of older farm families as a result of adding annuity to money income, by size of money income, 1966[1]

Money income size class	Distribution by money income	Income-annuity size class: Less than $2,500	$2,500-$4,999	$5,000-$9,999	$10,000-$14,999	$15,000-$24,999	$25,000 or more
	Thou.	*Thou.*	*Thou.*	*Thou.*	*Thou.*	*Thou.*	*Thou.*
Less than $2,500	308	99	156	41	7	5	
$2,500-$4,999	126		22	85	16	2	1
$5,000-$9,999	64			24	25	10	5
$10,000-$14,999	6					5	1
$15,000-$24,999	6					4	2
$25,000 or more	4						4
Total	514	99	178	150	48	26	13

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

farm sector via farm commodity programs, directly affecting the level of well-being as measured here. Economists often argue that many of the benefits from farm programs get capitalized into land values and thus may affect the level of net worth more than money income. This is because benefits are tied directly to land resources rather than family need. If these programs were expanded until the level of money income of farm families equaled that of nonfarm families, the economic well-being of farm families might well exceed that of the nonfarm group. From society's point of view, it may be more desirable to provide direct income support to families in the farm sector than to further enhance the level of net worth.

References

(1) Boyne, David H. Changes in the Income Distribution in Agriculture. Jour. Farm Econ. 47(5):1213-1224, Dec. 1965.

(2) Carlin, Thomas A. Farm Families Narrow the Income Gap During the 1960's. Agr. Finance Rev. 33:22-26, June 1972.

(3) Carlin, Thomas A., and Edward I. Reinsel. Combining Income and Wealth: An Analysis of Farm Family "Well-Being." Amer. Jour. Agr. Econ. 55(1):38-44, Feb. 1973.

(4) Evans, Carson D., and others. The Balance Sheet of

the Farming Sector, 1971. U.S. Dept. Agr., Agr. Inform. Bul. No. 356, Dec. 1971.
(5) Lansing, John B., and John Sonquist. A Cohort Analysis of Changes in the Distribution of Wealth. Six Papers on the Size Distribution of Wealth and Income, Studies in Income and Wealth, No. 33, Nat. Bur. Econ. Res., 1969.
(6) Projector, Dorothy S., and Gertrude S. Weiss. Survey of Financial Characteristics of Consumers. Board of Governors of the Federal Reserve System, Aug. 1966.
(7) Public Health Service. Vital Statistics of the United States, 1966—Life Tables, Vol. 11, Sec. 5. U.S. Dept. of Health, Education, and Welfare, 1968.
(8) Reinsel, Edward I. People with Farm Earnings—Sources and Distribution of Income. U.S. Dept. Agr., Econ. Res. Serv., ERS-498, Mar. 1972.
(9) Tweeten, Luther. Foundations of Farm Policy. Univ. Nebr. Press, Lincoln, 1970.
(10) U.S. Department of Agriculture. Farm Income Situation. U.S. Dept. Agr., Econ. Res. Serv., FIS-220, July 1970.
(11) U.S. Department of Commerce. Income in 1966 of Families and Persons in the United States. Bur. Census, Series P-60, No. 53, Dec. 28, 1967.
(12) U.S. Department of the Treasury. Statistics of Income 1966, Business Income Tax Returns. Internal Revenue Service Pub. 438, June 1969.
(13) Weisbrod, Burton A., and W. Lee Hansen. An Income-Net Worth Approach to Measuring Economic Welfare. Amer. Econ. Rev., Vol. 63, No. 5, Dec. 1968.
(14) Weitzman, Murry S. Measures of Overlap of Income Distributions for White and Negro Families in the United States. Bur. Census Tech. Paper-22, Apr. 1970.

Appendix

Three annuity rates were used in conjunction with a 4-percent return to equity to test the sensitivity of the system. The first combination assumed that the annuity rate and the return to equity were both 4 percent. The second combination assumed a slightly better rate of return on the annuity than could be obtained on equity—6 percent. The last case assumed that the annuity interest rate was 10 percent, greatly exceeding the return to equity.

The annuity rate used had little effect on the inequality of the distribution of economic well-being (table A-1). The Gini ratio was reduced from 0.475 to 0.411 with the inclusion of net worth, assuming a 4-percent annuity. However, when the annuity rate was increased to 6 and 10 percent, the Gini ratio changed only slightly. Without a valid statistical test of significance for differences in the Gini ratio, the variations noted above cannot be evaluated as meaningful.

The annuity rate greatly affected the mean and median levels of economic well-being—a result which was not surprising. The higher the annuity rate, the higher the payment. The median increased $1,500 with a 4-percent annuity and $3,000 with a 10-percent annuity above that of money income alone. Although the percentage of families with incomes between $2,500 and $9,999 changed only slightly as the annuity rate increased, the percentage with incomes of less than $2,500 substantially decreased. Also, the percentage of families with incomes of $10,000 or more greatly increased as the annuity rate increased.

Table A-1.—Distribution of farm families by amount of money income plus annuity at alternative annuity rates, U.S. farm families, 1966[1]

Money income size class	Distribution by money income	Money income plus— 4-percent annuity	6-percent annuity	10-percent annuity
	Percent	*Percent*	*Percent*	*Percent*
Less than $2,500 .	32	17	15	11
$2,500-$4,999 . .	26	26	24	20
$5,000-$9,999 . .	30	39	39	38
$10,000-$14,999 .	8	13	14	18
$15,000-$24,999 .	3	4	6	9
$25,000 or more .	1	1	2	4
	Dollars	*Dollars*	*Dollars*	*Dollars*
Mean	5,300	6,900	7,600	9,200
Median	4,200	5,700	6,100	7,200
Gini ratio	.475	.411	.414	.415

[1] Based on tabulations from the 1966 Pesticide and General Farm Survey.

Footnotes

[1] Italic numbers in parentheses refer to items in References, page 68.

[2] The annuity formula gives more weight to net worth as the age of the family head increases. An older individual can enjoy a higher level of consumption from a given net worth over his remaining lifetime than a younger individual.

509-051 O - 73 - 2

[3]The annuity principle allows for both an interest return and the consumption of the principle over the lifetime of the individual. It is the interest return during the first year of the annuity that we wish to avoid double counting. The return to capital is merely subtracted out and then added back in as interest.

[4]Farm production regions: Northeast–Maine, N.H., Vt., Mass., R.I., Conn., N.Y., N.J., Pa., Del., Md.; Appalachian–Va., W. Va., N.C., Ky., Tenn.; Southeast–S.C., Ga., Fla., Ala.: Delta–Miss., Ark., La.: Corn Belt–Ohio, Ind., Ill., Iowa., Mo.; Lake States–Mich., Wis., Minn.; Northern Plains–N. Dak., S. Dak., Nebr., Kans.; Southern Plains–Okla., Tex,; Mountain–Mont., Idaho, Wyo., Colo., N. Mex., Ariz., Utah, Nev.; Pacific–Wash., Oreg., Calif.

[5]The results were expected to be sensitive to both the rate of return to capital and the interest rate used in calculating the annuity. Three combinations of these were used to test the sensitivity of the system. The results are presented in the appendix.

[6]Projector and Weiss estimated the average net worth of all U.S. families and unrelated individuals in 1962 at $20,980. For comparison, an index of proprietor's equities in agriculture was developed and used to deflate the net worth of farm families in 1966 to 1962 levels. The resulting figure for all U.S. farm families was $40,110.

[7]Several alternatives are available to older farm families for liquidating their real estate assets for use as retirement income. However, many older low-income farm people own real estate which they cannot sell without losing their home and a major source of income. A program has been suggested which would allow older farm people to consume their equity over time while still retaining the other benefits of property (*3*).

A Methods Note on the Gauss-Seidel Algorithm for Solving Econometric Models

By Dale Heien, Jim Matthews, and Abner Womack

A particular numerical analytical technique for solving systems of simultaneous equations which offers several advantages to the user over other numerical techniques is discussed. The Gauss-Seidel algorithm is simply an iterative technique which requires no derivatives, matrix inversion, eigenvalue computation, or any other sophisticated numerical methodology. While the technique has been used successfully by a few large scale model builders and by the authors for several commodity models, the experience gained in the use of the technique has not been generally disseminated. Obtaining convergence with such an iterative technique is critically dependent on a number of factors which are taken up in some detail by the authors.

Keywords: Solutions, mathematical analysis, numerical, methodology, nonlinear, equations.

Once an econometric model has been specified and estimated, the next step involves some procedure to solve the model. This is done to obtain the reduced-form multipliers and to make forecasts for some future period or to examine the model's "track record" over the period of fit. The typical textbook approach to this problem is to treat the model as a set of simultaneous linear equations. In the conventional matrix terminology we have

$$\beta y + \Gamma x = 0$$

where β is a $G \times G$ matrix of coefficients of the endogenous variables, y is a $G \times 1$ vector of endogenous variables, Γ is a $G \times K$ matrix of coefficients on the exogenous variables, and x is a $K \times 1$ vector of exogenous variables. The solution, or reduced form, of the model is

$$y = -\beta^{-1} \Gamma x = \pi x$$

where

$$\pi_{ij} = \frac{\partial_{yi}}{\partial_{xj}}$$

is the $G \times K$ matrix of reduced-form multipliers. The main problem here is the calculation of β^{-1}, and this can be accomplished by well-known numerical techniques.

Unfortunately, few econometric models can be represented by a set of linear equations. For example, fundamental identities (such as price times quantity equals total revenue) as well as many other basic variables (relative prices, real income, etc.), form ratios that render the model nonlinear. In the past, this nonlinear impasse was handled in three ways. First, the nonlinear relations in the model could be linearized by using the first-order terms of a Taylor series expansion of the function.[1] Second, classical Newtonian numerical analytic techniques could be applied to solve simultaneous nonlinear equations. Third, the model was simply never solved. Unfortunately, the third route was often the one chosen. The advent of large scale models, such as the Brookings-SSRC model with extensive nonlinearities, rendered the first two approaches uneconomical and cumbersome. Attempts were also made to divide the model into linear blocks with nonlinear relations between them. Iterative techniques were then proposed to bridge these blocks.[2]

Recently, large scale model builders have rediscovered an old numerical analytic technique for solving linear and nonlinear simultaneous equations. This technique is the Gauss-Seidel method. The Gauss-Seidel method is simply an iterative technique which requires no derivatives, matrix inversion, eigenvalue computation, or any other sophisticated numerical methodology. Writing the equations of the model in the following form,

$$\begin{aligned} y_1 &= f_1(y_2, y_3, \ldots, y_G, x_1, x_2, \ldots, x_K) \\ y_2 &= f_2(y_1, y_3, \ldots, y_G, x_1, x_2 \ldots, x_K) \\ &\vdots \\ y_G &= f_G(y_1, y_3, \ldots, y_{G-1}, x_1, x_2, \ldots, x_K) \end{aligned}$$

Footnotes are on p. 75.

$$y^0 = (y_2^0, y_2^0, \ldots, y_G)$$

we can compute a first round of y's (y^1) from these initial guesses

$$y_1^1 = f_1 \, (y_2^0, y_3^0, \ldots, y_G^0, x_1, x_2, \ldots, x_K)$$

$$y_2^1 = f_2(y_1^1, y_3^0, \ldots, y_G^0, x_1, x_2, \ldots, x_K)$$

$$\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$$

$$y_G^1 = f_G(y_1^1, y_2^1, y_3^1, \ldots, y_{G-1}^0, x_1, x_2, \ldots, x_K).$$

These first-round guesses can now be used to generate a second round (y^2) according to

$$y_1^2 = f_1 \, (y_2^1, y_3^1, \ldots, y_G^1, x_1, x_2, \ldots, x_K)$$

$$y_2^2 = f_2(y_1^2, y_3^1, \ldots, y_G^1, x_1, x_2, \ldots, x_K)$$

$$\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$$

$$y_G^2 = f_G(y_1^2, y_2^2, y_3^2, \ldots, y_{G-1}^2, x_1, x_2, \ldots, x_K).$$

This iteration scheme is repeated until some specified tolerance level is reached so that

$$|(y_i^k - y_i^{k-1})/y_i^{k-1}| \leqslant \delta$$

where δ is a small positive number.

Whether a solution exists for any given econometric model is a problem aside from the use of the Gauss-Seidel technique. One necessary but not sufficient condition is that the number of equations equals the number of unknowns. Although equality between the number of equations and the number of unknowns is no guarantee that a solution exists, in practice this is the main consideration. More common is the phenomenon of multiple solutions. A relation such as the "Phillips" curve

$$\dot{w} = \beta_0 + \beta_1 \, UR^{-1}$$

where $\dot{w}$ is the percent change in money wages and UR is the unemployment rate is defined in the first and third quadrants. Hence, it is possible to have solutions to the model which yield falling wages at negative unemployment rates. If multiple solutions should occur, computer program statcments can be included to force the model solution out of those regions that do not apply or that are a priori unreasonable.

If we proceed on the basis that a unique solution exists for some simultaneous set of nonlinear equations, numerical routines such as the Gauss-Seidel algorithm provide many advantages over classical nonlinear methods. However, obtaining convergence with this technique is critically dependent on (1) normalization, (2) the ordering of the equations, and (3) the use of dampening factors.

The Problem of Normalization

Suppose that an equation has been fitted for a particular endogenous variable and that other endogenous variables are contained in this relationship. It is possible to renormalize this equation on one of the other endogenous variables. However, convergence of the system can be shown to depend on which of the variables is on the left side of the equation. This is demonstrated for a simple two-variable, two-equation case as follows:

$$y_1 + .2y_2 = 4$$

$$-y_1 + y_2 = 2$$

where the analytical solution is $y_1 = 3, y_2 = 5$.

The following normalization gives a converging system:

$$y_1 - 4 = .2y_2$$

$$y_2 = 2 + y_1$$

Let $y_0 = (y_1^0, y_2^0) = (15, 15)$.[3] Then the iteration sequence becomes:

$$y_1^1 = 4 - .2(15) = 1, y^1 = (1, 3)$$

$$y_2^1 = 2 + 1 = 3$$

$$y_1^2 = 4 - .2(3) = 3.4, y^2 = (3.4, 5.4)$$

$$y_2^2 = 2 + 3.4 = 5.4$$

$$y_1^3 = 4 - .2(5.4) = 2.92, y^3 = (2.92, 4.92)$$

$$y_2^3 = 2 + 2.92 = 4.92$$

$$y_1^4 = 4 - .2(4.92) = 3.016, y^4 = (3.016, 5.016)$$

$$y_2^4 = 2 + 3.016 = 5.016$$

$$y_1^5 = 4 - .2(5.016) = 2.9968, y^5 = (2.9968, 4.9968)$$

$$y_2^5 = 2 + 2.9968 = 4.9968$$

$$\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$$

It can be seen from the above sequence that for a given $\delta > 0$ this normalization will converge to a set such that $|(y_i^k - y_i^{k-1})/y_i^{k-1}| \leqslant \delta$ where δ is some predetermined tolerance level.

The following normalization of the same model, however, would result in a diverging system:

$$y_2 = 20 - 5y_1$$

$$y_1 = -2 + y_2$$

Let $y_0 = (15, 15)$. Then the iteration sequence becomes:

$$y_2^1 = 20 - 5(15) = -55, y^1 = (-57, -55)$$

$$y_1^1 = -2 + (-55) = -57$$

$$y_2^2 = 20 - 5(-57) = 305, y^2 = (303, 305)$$

$$y_1^2 = -2 + (305) = 303$$

$$y_2^3 = 20 - 5(303) = -1495, y^3 = (-1497, \ -1495)$$

$$y_1^3 = -2 + (-1495) = -1497$$

$$\begin{array}{cc} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{array}$$

Obviously this normalization choice will not converge to the solution set.

Use of the Gauss-Seidel algorithm requires a unique dependent variable for each equation. Experience has shown that convergence is enhanced if the dependent variable is the one which was normalized on in the regression used to obtain the estimate. If, for example, an equation is fitted by least squares with y_1 as the dependent variable and then solved for some other variable as dependent (say y_2), then the model will sometimes not converge. However, if the equation is refitted with y_2 as the dependent variable, the convergence problem frequently disappears. Furthermore, specification of an econometric model where each equation has a unique dependent variable makes a great deal of sense from the causal point of view.[4]

Ordering of the Equations

By the notion of ordering is meant the order in which the equations are positioned so that iterative computation can take place. The procedure suggested is to arrange the equations so that the matrix of endogenous variables would be as triangular as possible.[5] Consider, for example, the following set of five equations where y_i, $i = 1, \ldots, 5$ is the set of endogenous variables and z_i, $i=1, \ldots, 5$ is some set of exogenous variables:

$$y_1 = f(y_2, y_5, z_1)$$

$$y_2 = f(y_3, z_2)$$

$$y_3 = f(y_2, y_1, z_3)$$

$$y_4 = f(y_1, z_4)$$

$$y_5 = f(y_2, z_5)$$

A first attempt at a solution set for the above system could be determined by ordering the equations as outlined above. This ordering is illustrated in matrix form in exhibit A. The x's in the matrix represent the endogenous variables in each equation.

Exhibit A

	Variable				
Equation	y_1	y_2	y_3	y_4	y_5
y_4	x			x	
y_5		x			x
y_3	x	x	x		
y_2		x	x		
y_1	x	x			x

As can be readily observed, it is not possible to order the equations so that a triangular matrix is obtained. However, this ordering is as triangular as possible. A first attempt at a solution would be to use the ordering y_4, y_5, y_3, y_2, y_1. If this sequence does not coverge it will most likely be caused by the position of y_4 and y_5 since these two equations have variables outside the triangular block. Should this ordering diverge, the ordering y_4, y_1, y_3, y_2, y_5 could be tried. Where convergence is not obtained after several orderings have been tried, the suspect equations should be pulled out of the system. If the remaining equations converge, then more careful attention should be given to the equations preventing convergence. It could be a problem of normalization or a simple mechanical error in the equation. It is also possible that the Gauss-Seidel technique cannot find a solution. However, inability to find a solution using this technique has not been a problem in models solved by

the authors. Where convergence has been a problem, the use of a dampening factor has frequently been beneficial.

Use of a Dampening Factor

A dampening factor may be applied to any one or all of the equations to aid in obtaining convergence. An integer k, for $0 < k < 1$, is multiplied by y_i^m, the mth equation in the interdependent system, where m represents the iteration number. $(1-k)$ times y_i^{m-1} is then added to the equation, so that

$$y_i^m = k \cdot y_i^m + (1-k) y_i^{m-1} \quad i = 1, \ldots, G$$

A primary reason for using a dampening factor is that it helps prevent a diverging arrangement of the equations from dominating the system. A dampening factor in effect allows other equations more rounds to converge and tends to pull the diverging arrangement back toward convergence. As an example, consider again the diverging system presented earlier and let $k = .25$.

$$y_2 = 20 - 5y_1$$

$$y_1 = -2 + y_2$$

We have already seen that this normalization will not lead to convergence even though the system of equations has a solution set $y_1 = 3, y_2 = 5$.

Let $y^0 = (y_1^0, y_2^0) = (15, 15)$ where the dampened system is given by

$$y_2^m = y_2^{m-1}(1-.25) + .25\,(20-5y_1)$$

$$y_1^m = y_1^{m-1}(1-.25) + .25(-2+y_2)$$

Plugging y_0 in the initial starting set in the above equation will lead to convergence after approximately 25 iterations.

The comments presented cover the basic considerations in using the Gauss-Seidel algorithm to solve systems of simultaneous equations. Additional discussions of numerical techniques can be found in (*3, 6, 9, 11*). Computer programs incorporating the Gauss-Seidel algorithm have been prepared by Norman and also by Green and Pritchard (*5, 10*). The computer program prepared by Green and Pritchard varies slightly from the one suggested by Norman and was used by the authors in preparing computer simulation programs for beef, pork, broilers, turkeys, eggs, oranges, and soybeans. Though these models are relatively small (7 to 35 equations), the authors felt that substantial savings in computer costs and time could be attributed to the use of the Gauss-Seidel algorithm. Each of the models required extensive testing in its initial development. This frequently involved use of alternative equations which could be easily interchanged in the Gauss-Seidel routine as opposed to the more cumbersome matrix inversion approach to obtain the reduced-form solution. In addition, some of these models contain price ratios and other forms of nonlinearities in the endogenous variables which would have required linear approximations by the Taylor series if the reduced-form technique had been used to obtain a solution.

The typical cost of obtaining a model solution with the Gauss-Seidel technique ranged from \$3 to \$5 for these models, or about half the cost of the matrix inversion approach. A subroutine for obtaining the impact multipliers is included. The programs for these agricultural models are available from the author on request. A typical program for an 18-equation simultaneous model of the U.S. beef economy is given in the appendix to this report.

Bibliography

(1) Evans, Michael K. "Computer Simulation of Nonlinear Econometric Models." Discussion paper No. 97, Univ. Pa.

(2) Evans, Michael K. "An Agricultural Submodel for the United States Economy." Essays in Industrial Econometrics, Vol. II, Studies in Quantitative Economics No. 4, Univ. Pa., pp. 63-146, 1969.

(3) Evans, Michael K. "Nonlinear Econometric Models." From T. H. Naylor, ed., The Design of Computer Simulation Experiments, Duke Univ. Press, pp. 369-373, 1969.

(4) Fisher, Franklin, M. "A Correspondence Principle for Simultaneous Equation Models." Econometrica, Vol. 38, No. 1, Jan. 1970, pp. 73-92.

(5) Green, George, R. and J. K. Pritchard. A General Purpose Computer Program to Simulate and Forecast with Econometric Models. Staff Paper No. 17, U.S. Dept. Commerce, Off. Bus. Econ., July 1970.

(6) Holt, Charles C. et al. Program Simulate II. Soc. Systems Res. Inst., Univ. Wis., 1967.

(7) Holt, Charles C. "Validation and Application of Macro Economic Models Using Computer Simulation." The Brookings Quarterly Econometric Model of the United States, Rand McNally, 1964, pp. 637-652.

(8) Howrey, Philip and H. H. Kelejian. "Simulation

Versus Analytical Solutions: The Case of Econometric Models." Computer Simulation Experiments with Models of Economic Systems, Thomas H. Naylor, ed., John Wiley and Sons, Inc., 1971, pp. 299-318.

(9) Naylor, Thomas H. Computer Simulation Experiments with Models of Economic Systems, John Wiley and Sons, Inc., 1971.

(10) Norman, M. R. "Solving a Nonlinear Econometric Model." Paper presented at the December 1967 meetings of the Econometric Society.

(11) Westlake, Joan R. A Handbook of Numerical Matrix Inversion and Solution of Linear Equations. John Wiley and Sons, Inc., 1968.

(12) Womack, Abner W. and Jim L. Matthews. "Linear Approximation of Nonlinear Relationships by the Taylor's Series Expansion Revisited." Agr. Econ. Res., Vol. 24, No. 4, pp. 93-101, Oct. 1972.

Footnotes

[1] Considerations in the use of the Taylor series to obtain linear approximations have been discussed previously in this journal by Womack and Matthews (*12*). (Italic numbers in parentheses indicate items in the References, p. 73.)

[2] This approach is reported by C. Holt (*7*).

[3] Any real number for y_2^0 will suffice since y_2^0 is not used in the iterative computation.

[4] For further elaboration of this concept, see Fisher (*4*).

[5] Experience with interdependent model systems indicates that the more nearly the equations are aligned in a causal chain, stimulus-response form, the higher is the probability of obtaining convergence. This leads to a form that is as recursive and hence as triangular as possible.

Appendix: Computer Program for Beef With Gauss-Seidel Subroutine

```
FORTRAN IV G1  RELEASE 2.0          MAIN          DATE = 73115          15/07/30          PAGE 0001

           COMMON Y(160),YO(160),Y4(160),X(160),Z(160),N,XE,A(160)
C          1950-65 CLS BEEF
      22   FORMAT(1X,E14.8,7E15.8)
      8    FORMAT(1X,3E15.8,I10)
       903 FORMAT (8I10)
      190  FORMAT(1X,E14.8,7E15.8)
      191  FORMAT(1X,5E15.8,I10)
      2    FORMAT(5F15.6)
      291  FORMAT (I10)
      98   FORMAT(1H1)
           N=19
           N1=16
        55 READ(5,2)(Y(I),I=1,N)
        57 READ(5,2)(X(I),I=1,N)
        58 READ(5,2)(Z(I),I=1,N1)
           Z(15)=31908000.
           DO 893 I=1,N
           A(I)=Y(I)
      893  CONTINUE
           M=0
      3    CONTINUE
           DO 56 I=1,N
        56 YO(I)=Y(I)
           M=M+1
           WRITE(2,22)(Y(I),I=1,N)
           WRITE(2,22)(X(I),I=1,N)
           WRITE(2,22)(Z(I),I=1,N1)
      2021 N63=0
      502  CONTINUE
           DO 4 I=1,N
      4    Y4(I)=Y(I)
           NICK=600
           IF(N63-NICK) 201,202,202
      201  CONTINUE
           N63=N63+1
      192  FORMAT(I10)
           CALL CEN
           DO 503 I=1,N
           DIF1=(Y(I)-Y4(I))/Y4(I)
           IF(DIF1) 505,503,505
      505  CONTINUE
           DIF2=0.0
           DIF2=ABS (DIF1)
           IF(DIF2-.0002) 503,503,502
      503  CONTINUE
           DO 504 I=1,N
      504  Y4(I)=Y(I)/YO(I)
      290  FORMAT(1X,E15.8,I10)
```

```
202   DO 10 I=1,N
      Y4(I)=Y(I)/YO(I)
      WRITE(2,8) Y(I),YO(I),Y4(I),I
10    CONTINUE
      WRITE(2,291) N63
      WRITE(2,98)
      DO 126 I=1,N
      YO(I)=Y(I)
126   CONTINUE
      DO 125 I=1,N
      X(I)=YO(I)
125   CONTINUE
      READ(5,2)(Y(I),I=1,N)
      READ(5,2)(Z(I),I=1,N1)
      Z(15)=X(15)
      NZ=M-10
      IF(NZ) 3,3,5
5     CONTINUE
      STOP
      END
```

```
FORTRAN IV G1  RELEASE 2.0              CEN              DATE = 73115          15/07/30                PAGE 0001

0001                      SUBROUTINE CEN
0002                      COMMON Y(160),YO(160),Y4(160),X(160),Z(160),N,XE,A(160)
0003                      WC=.5
0004                      W=1.0-WC
                C
                C         TOTAL SUPPLY OF BEEF                             Y(1)      TSB
                C
0005                      Y(1)= Y(2) + Z(1) + Z(2)
0006                      Y(1)=WC*Y(1)+W*Y4(1)
                C
                C         TOTAL PRODUCTION OF BEEF                         Y(2)      TPB
                C
0007                      Y(2)= Y(3) + Y(4)
0008                      Y(2)=WC*Y(2)+W*Y4(2)
                C
                C         TOTAL PRODUCTION OF FED BEEF                     Y(3)      TPFB
                C
0009                      Y(3)=-678150140.0 + 631.29*Y(5) + 692321280.*Y(9)/Z(3)
0010                      Y(3)=WC*Y(3)+W*Y4(3)
                C
                C         TOTAL PRODUCTION OF NONFED BEEF                  Y(4)      TPNFB
                C
0011                      Y(4)=-1160867100. + 466.28*(Y(6)+Y(7)+Y(8)) + 1563341600.*Y(9)/Z(3
                         1)
0012                      Y(4)=WC*Y(4)+W*Y4(4)
                C
                C         FED BEEF HEIFER AND STEER SLAUGHTER              Y(5)      FBHSS
                C
0013                      Y(5)=Z(14)*Y(11)
0014                      Y(5)=WC*Y(5)+W*Y4(5)
                C
                C         NONFED BEEF HEIFER AND STEER SLAUGHTER           Y(6)      NFBHSS
                C
0015                      Y(6)= Y(11)-Y(5)
0016                      Y(6)=WC*Y(6)+W*Y4(6)
                C
                C         BEEF HEIFER AND STEER SLAUGHTER                  Y(11)     BHSS
                C
0017                      Y(11)=-2759537. + .68705*X(15) + .17975*Z(15) - 26354.9*X(14) + 26
                         1832.1*Y(14)
0018                      Y(11)=WC*Y(11)+W*Y4(11)
                C
                C         NONFED DAIRY COW SLAUGHTER                       Y(8)      NFDCS
                C
0019                      Y(8)=1427995.0 + .10650 *Z(4) + .26938 *X(8) +45527.1 *Y(10)-
                         196830.8*X(10)
0020                      Y(8)=WC*Y(8)+W*Y4(8)
                C
```

```
              C      NONFED BEEF COW SLAUGHTER                        Y(7)      NFBCS
              C
 0021                Y(7)= 833297.4 + .18539*X(15) - 152481.8*Y(14)
 0022                Y(7)=WC*Y(7)+W*Y4(7)
              C
              C      TOTAL NUMBER OF CATTLE SLAUGHTERED               Y(12)     TNCS
              C
 0023                Y(12)= Y(8) + Y(7)  + Y(11)
 0024                Y(12)=WC*Y(12)+W*Y4(12)
              C
              C      BEEF HEIFERS FOR BREEDING                        Y(13)     BHFB
              C
 0025                Y(13)=-4976911.0 + 30760.9*X(14) + 104886.3*Z(7) + 9046.7*Z(8) +
                    1 .21127*X(15)
 0026                Y(13)=WC*Y(13)+W*Y4(13)
              C
              C      RETAIL PRICE OF BEEF                             Y(9)      RPB
              C
 0027                Y(9)=(.0021158-(.15586E-04)*Y(19)/Z(13)-(.83906E-05)*Y(18)/Z(13)-(
                    1.14793E-05)*Z(10)/Z(13)+.21576*Z(11)/(Z(9)/Z(13))-.6797*Z(5)/(Z(9)
                    1/Z(13)))*(Z(9)/Z(13))
 0028                Y(9)=WC*Y(9)+W*Y4(9)
              C
              C      PRICE OF NONFED CATTLE                           Y(10)     PNFC
              C
 0029                Y(10)= -3.2517 + .8422*Y(14) - .0785*Z(6)
 0030                Y(10)=WC*Y(10)+W*Y4(10)
              C
              C      BEEF COW INVENTORY                               Y(15)     BCI
              C
 0031                Y(15)=X(15)+Y(13)-Y(7)-.02*X(15)
 0032                Y(15)=WC*Y(15)+W*Y4(15)
              C
              C
              C      PRICE OF FED CATTLE                              Y(16)     PFEC
              C
 0033                Y(16)=Y(9)*(27.72 - (.3531E-06)*Y(11)+7.84*Y(9)/Z(16))
 0034                Y(16)=WC*Y(16)+W*Y4(16)
 0035                Y(17)=WC*Y(17)+W*Y4(17)
              C
              C
              C      TOTAL SUPPLY OF FED BEEF                         Y(18)     TSFB
 0036                Y(18)=Y(3)
 0037                Y(18)=WC*Y(18)+W*Y4(18)
              C
              C      TOTAL SUPPLY OF NONFED BEEF                      Y(19)     TSNFB
 0038                Y(19)=Y(1)-Y(18)
              C      PRICE OF FEEDER CATTLE                           Y(14)     PFC
```

```
                  C
 0039                   Y(14)=Y(9)*(16.879-(.2863E-06)*Y(11)+7.6285*Y(9)/Z(3)+11.05*Y(9)/Z
                       1(16))
 0040                   Y(14)=WC*Y(14)+W*Y4(14)
                  C     BEEF IMPORTS                                     Z(1)      BI
                  C     BEEF STOCKS                                      Z(2)      BS
                  C     PRICE OF CORN                                    Z(3)      PC
                  C     DAIRY COW INVENTORY                              Z(4)      DCI-1
                  C     PRICE OF ALL OTHER ND+S                          Z(5)      PAO
                  C     TIME 1965=16.0                                   Z(6)      T
                  C     PRICE OF FEEDER CATTLE-2                         Z(7)      PFC-2
                  C     PRICE OF FEEDER CATTLE-3                         Z(8)      PFC-3
                  C     PERSONAL CONSUMPTION EXPENDITURES ND+S           Z(9)      PSCENDS
                  C     TOTAL SUPPLY OF PORK                             Z(10)     TSP
                  C     PRICE OF POULTRY                                 Z(11)     PCHICK
                  C     PRICE OF CORN-1                                  Z(12)     PC-1
                  C     POPULATION                                       Z(13)     POP
                  C     RATIO OF FBHSS/BHSS                   Z(14)       R
                  C     WAGE RATE IN MEAT PROCESSING                     Z(15)     WR
 0041                   RETURN
 0042                   END
```

A Dynamic Model of the U.S. Tobacco Economy

By Jitendar S. Mann

A 14-equation recursive model is developed for (1) flue-cured acreage, (2) burley acreage, (3) flue-cured price, (4) burley price, and (5) consumer demand for cigarettes. The coefficients are estimated using data for 1954-70. The reduced form and the impact multipliers are derived. The multipliers are used to illustrate the impact of a 3.5-cent increase in the support rate for flue-cured tobacco. A comparison of the reduced-form estimated values with observed values of 14 endogenous variables showed a good fit for the model over the period studied.

Keywords: Flue-cured, burley, recursive model, multipliers.

Recent public consciousness about the problem of smoking and health, and changes in advertising policy for cigarettes are critical factors which may modify the demand for tobacco products. The production, distribution, and manufacturing processes are faced with several potential technological innovations (*3*).[1] These, combined with Government policy programs aimed at controlling the supply of certain types of tobacco, are the major features of the dynamics of the tobacco market.

To analyze the effects of potential changes, an econometric model of the U.S. tobacco economy is constructed. The model, based on annual data, will be useful in studying long-run changes in the tobacco economy.[2] The model includes five behavioral equations: (1) flue-cured leaf production, (2) burley leaf production, (3) flue-cured leaf price, (4) burley leaf price, and (5) consumer demand for cigarettes. Flue-cured and burley tobacco account for over 90 percent of total tobacco production. These two types of tobacco, along with small quantities of Maryland and imported oriental types, are used in the manufacture of cigarettes. The analysis thus includes the major part of the U.S. tobacco economy.

Flue-cured tobacco is grown mainly in Virginia, North Carolina, South Carolina, Georgia and Florida. Burley is produced principally in Kentucky, Tennessee, Ohio, Indiana, West Virginia, Virginia, North Carolina and Missouri. After harvesting, the tobacco is cured, a process which involves drying by the application of regulated heat for flue-cured and air circulation for burley. The cured tobacco is moved to the auction market for sale. There it is purchased by representatives of manufacturers or dealers, or if it is eligible for price support and the bid is not high enough, it is taken by the cooperative association. In either case it is put into storage after redrying or stemming.

The two important features of Government policy are marketing quotas and price support. A national marketing quota for each type of tobacco is proclaimed for 3 years, and the quota for each year is announced annually. Acreage allotments are used to implement the marketing quotas for tobacco.[3] These quotas have to be approved by the producers in a referendum every 3 years. A national quota is proclaimed if the total supply exceeds the reserve supply level. The reserve supply is the normal supply plus 5 percent to meet domestic and foreign demand in years of drought, flood, and other adverse conditions. Normal supply is the normal year's domestic consumption and exports (average domestic consumption and exports for the last 10 marketing years adjusted for trends) plus 175 percent of a normal year's domestic consumption and 65 percent of a normal year's export as an allowance for a normal carryover.

For those years in which the marketing quota has not been disapproved by the producers, the support level is determined by adjusting the 1959 support price upward or downward in proportion to a change in a 3-year moving average of the parity index. If the marketing quota is disapproved by the producers, no price support is available for that year.

The model is set up in terms of a recursive system including supply equations, leaf price equations, and cigarette demand equation. These behavioral equations are tied together into the system by a set of identities

Footnotes are on p. 85.

describing certain technical and marketing characteristics of the tobacco economy.

Variables

The following 14 variables are treated as endogenous in the system. They are recursively determined in a system of 14 equations by the predetermined variables included in the system. The dividing line between endogenous and predetermined variables is arbitrary and changes as the scope of research expands. For example, behavioral equations can be developed for tobacco and cigarette exports, and those variables will move from the predetermined to the endogenous group.

AF_t = acreage of flue-cured tobacco (1,000 acres)

AB_t = acreage of burley tobacco (1,000 acres)

PF_t = average price per pound to growers, flue-cured (cents per pound)

PB_t = average price per pound to growers, burley (cents per pound)

QPF_t = production of flue-cured tobacco (million pounds)

QPB_t = production of burley (million pounds)

SF_{t+1} = year-end inventory, flue-cured (million pounds)

SB_{t+1} = year-end inventory, burley (million pounds)

DF_t = flue-cured tobacco used in cigarette manufacturing (million pounds)

DB_t = burley tobacco used in cigarette manufacturing (million pounds)

QC_t = per capita cigarette consumption (in terms of population 18 years old and over)

QCC_t = total domestic cigarette consumption (billions)

PC_t = consumer price index for tobacco products, deflated by the consumer price index (1967 = 100)

QCP_t = production of cigarettes (billions).

The following variables are treated as predetermined in the present analysis. These variables include policy, technological, and other outside factors affecting the tobacco economy.

ALF_t = acreage allotted, flue-cured (1,000 acres)

ALB_t = acreage allotted, burley (1,000 acres)

SF_t = beginning year stocks of flue-cured (million pounds)

SB_t = beginning year stocks of burley (million pounds)

SPF_t = support price, flue-cured (cents per pound)

SPB_t = support price, burley (cents per pound)

QF_t = percent of total flue-cured crop which is choice, fine, and good quality

QB_t = percent of burley crop which is choice, fine, and good quality

XF_t = exports of flue-cured tobacco (million pounds)

XB_t = exports of burley tobacco (million pounds)

ODF_t = flue-cured tobacco used for other products (million pounds)

ODB_t = burley tobacco used for other products (million pounds)

FL_t = percent of cigarettes filter-tipped

I_t = per capita disposable income (1958 dollars)

QCX_t = quantity of cigarettes exported (billion)

The following multiplicative factors are used to make the units in various markets comparable. Values for these factors for each year can be inserted in the system and will satisfy the necessary equilibrium condition. However, to simplify the computational work, average values for the 3-year period 1968-70 were used in the following analysis.

YF = yield per acre, flue-cured (1,000 pounds)

YB = yield per acre, burley (1,000 pounds)

F = pounds of flue-cured tobacco used per 1,000 cigarettes

B = pounds of burley tobacco used per 1,000 cigarettes

P = population 18 years old and over (billion)

The Model

The model consists of five behavioral equations and nine technological and market clearing identities. The system brings together the forces of Government policy, technological factors, market mechanism, and consumer decisionmaking.

The coefficients of the behavioral equations are estimated from data for 1954-70. As the system is recursive, the coefficients are estimated by ordinary least squares. The estimated model is discussed below. The values in parentheses under the coefficients are the t values of the coefficients. *DW* stands for the Durbin-Watson statistic, and is reported only for those equations in which the lagged value of the dependent variable is not included in the regression (*1*, p. 410). The squared multiple correlation has been corrected for degrees of freedom.

Both flue-cured and burley tobacco were subject to acreage allotments and price support during the years studied. (See, however, footnote 3.) The model takes these policy instruments into account. The acreage equations are of cobweb type. The acreage is a function of lagged acreage, lagged price, and acreage allotted.

$$(1)\ AF_t = -323.18040 + \underset{(0.84499)}{0.08671AF_{t-1}} + \underset{(2.33589)}{3.53768PF_{t-1}} + \underset{(10.10719)}{1.03551ALF_t}$$

$$R^2 = 0.978$$

$$(2)\ AB_t = -77.00651 + \underset{(1.55789)}{0.14865AB_{t-1}} + \underset{(0.50540)}{0.33717PB_{t-1}} + \underset{(16.21848)}{1.01089ALB_t}$$

$$R^2 = 0.984$$

In each case the variables included explain 98 percent of the variation in acreage. The signs of the coefficients are also correct. The acreage allotted has a strong effect on acres harvested as indicated by the high t values. From these acreage estimates, production is obtained by multiplying by average yield.

$$(3)\ QPF_t = YF \times AF_t$$

$$(4)\ QPB_t = YB \times AB_t$$

Up to this stage, we have explained acreage and production (endogenous variables) in terms of predetermined variables only. This means that the model can be modified so that exogenously estimated acreage or production can be brought in at this stage. This enables us to study the effect of technological changes in the production sector in several ways and incorporate those into the model.

The price equations represent the process of price formation in the auction markets. The supply, consisting of production from current year's crop, is inelastic and must be sold as the farmer has very limited storage facilities. However, at the same time, the auction price has to be more than the support rate.[4] On the side of the buyers, the size of existing stocks to which the current purchases are to be added is a potential factor in determining the price bid.

$$(5)\ PF_t = -14.51534 - \underset{(0.22426)}{0.00109(QPF_t + SF_t)} + \underset{(4.15982)}{1.35435SPF_t} + \underset{(0.90356)}{0.26428QF_t}$$

$$R^2 = 0.884 \quad DW = 1.650$$

$$(6)\ PB_t = 59.90805 - \underset{(2.78366)}{0.02081\,(QPB_t + SB_t)} + \underset{(3.66681)}{0.51084SPB_t} + \underset{(4.10601)}{0.44542QB_t}$$

$$R^2 = 0.789 \quad DW = 1.403$$

During those years when producers approve the quota, the price support is available. The support rate sets the lower limit to the price in the auction markets. This explains the high t values for this variable in the above equations.

The tobacco markets satisfy the following market-clearing identities:

$$(7)\ SF_{t+1} - SF_t = QPF_t - DF_t - XF_t - ODF_t$$

$$(8)\ SB_{t+1} - SB_t = QPB_t - DB_t - XB_t - ODB_t$$

This means that the excess of production over domestic disappearance and export is inventory demand and is added to stocks of tobacco. In actual practice, production for the current year is added to the carryover, and tobacco for domestic disappearance and export comes out of aged stocks. This can be shown by rewriting the above identities appropriately.

In the absence of any limitations on the availability of data, we could postulate the following price linkage between the retail price of cigarettes and the price to growers for flue-cured and burley tobacco:

$$PC_t = a_1 PF_t + a_2 PB_t + M$$

where a_1 is the pounds of flue-cured tobacco required per pack of cigarettes, and a_2 the pounds of burley per pack. M is the marketing and manufacturing margin, including taxes and the cost of other tobaccos used. But we are using an index of consumer prices for tobacco products as a proxy for the retail price of cigarettes.[5] Moreover, a crudely defined margin, which includes heterogeneous items, will have no operational usefulness. Therefore, we use an empirically estimated equation which resembles the price linkage identity discussed above but the coefficients do not have a precise interpretation. The major role of this equation is to make the system complete.

$$(9)\quad PC_t = 40.34429 + 0.72355 PF_t + 0.14827 PB_t$$

Consumer demand for cigarettes is studied in terms of per capita consumption of cigarettes for the population 18 years old and over. The use of per capita consumption is based on the underlying consumer theory of the individual. Consumer demand is influenced by the habit-forming nature of the product and reaction to the issue of smoking and health. These factors are embodied in the lagged value of consumption and percent of cigarettes filter-tipped.

$$(10)\quad QC_t = 3302.04150 + \underset{(0.47442)}{0.07195 I_t} + \underset{(4.22992)}{0.72692 QC_{t-1}} - \underset{(3.43241)}{26.71665 PC_t} + \underset{(1.81266)}{9.50125 FL_t}$$

$$R^2 = 0.885$$

Total cigarette consumption is the product of per capita consumption and population 18 years and over.

$$(11)\quad QCC_t = P \times QC_t$$

The quantity of cigarettes produced has to satisfy the technical relationships in terms of flue-cured and burley tobacco disappearance.

$$(12)\quad DF_t = F \times QCP_t$$

$$(13)\quad DB_t = B \times QCP_t$$

Finally, to complete the system we have a market-clearing identity for cigarettes:[6]

$$(14)\quad QCP_t = QCC_t + QCX_t$$

Framework for Policy Analysis

This structural system of 14 equations and identities embodies the a priori specifications and restrictions of the model. The strategic technological and policy variables included in the structural system can be appropriately modified to trace the impact on the market. The system can be solved for the 14 endogenous variables to obtain the reduced form of the system. The reduced form, given in appendix table 1, expresses each endogenous variable as a linear function of the several predetermined variables, including the lagged endogenous variables. The table of reduced form gives the impact of per unit changes in an exogenous variable on each of the endogenous variables. For example, the effects of flue-cured acreage and price on the endogenous variables in the following year are given in the first two columns of the table. The reduced form was used to generate the estimated values of the 14 endogenous variables, which were compared with the observed values to evaluate the "track record" of the model. However, the estimates generated by a model can be no better than the data which are used.

However, for a dynamic analysis of the system, we can eliminate the lagged values of the endogenous variables by successive substitutions, obtaining a system of endogenous variables in terms of the exogenous variables only.[7] This system of multipliers for years 1-5 and the long-run multipliers are given in appendix tables 2-7.

To illustrate the use of the multipliers, consider a possible 5 percent increase in the support rate for flue-cured tobacco. This comes to an average of about 3.5 cents per pound. Using the coefficients from the column headed *SPF* in appendix tables 2-7, the effects on the following variables are calculated: Flue-cured acreage, flue-cured price, flue-cured year-end stocks, per capita cigarette consumption, flue-cured production, flue-cured cigarette use, cigarette consumption, retail tobacco price index, and cigarette production. These effects for years 1-5 and the long-run effects are given in table 1. Note that a rise in the support rate is estimated to lead to a rise in the price of flue-cured tobacco, increased production, and higher carryover. The higher price of tobacco is estimated to lead to higher tobacco product prices, decline in cigarette consumption and production, and, hence, less use of flue-cured tobacco in

Table 1.–Impact of a possible 3.5-cent increase in support rate for flue-cured tobacco

Variable	Year					Long run
	1	2	3	4	5	
Flue-cured acreage (1,000)	---	16.77	18.05	17.94	17.69	---
Flue-cured price (¢/lb.)	4.74	4.69	4.63	4.56	4.49	---
Flue-cured year-end stocks (million pounds)	12.9	67.00	129.84	196.62	265.47	4348.89
Per capita cigarette consumption (number)	–91.63	–156.51	–201.17	–230.64	–248.77	–.09
Flue-cured production (million pounds)	---	32.06	34.50	34.30	33.82	---
Flue-cured cigarette use (million pounds)	–12.9	–22.04	–28.33	–32.48	–35.03	---
Cigarette consumption (billion)	–12.14	–20.73	–26.64	–30.54	–32.95	–.01
Retail tobacco price (index)	3.43	3.36	3.27	3.16	3.04	---
Cigarette production (billion)	–12.14	–20.73	–26.64	–30.54	–32.95	–.01

cigarette manufacturing. These effects will, however, in practice be mitigated by the influence of other factors like exports and other policy variables. But the model enables us to isolate, for analytical purposes, the impact of a single possible policy change.

Another question which may be analyzed is the impact of increased exports (or reduced exports, assuming that an alternate source of supply, Rhodesia, opens up). A new reduced form can be calculated by changing the multiplicative factors, which represent the impact of technological change. The average yield per acre embodies the technological change in production[8] and the pounds of tobacco used per 1,000 cigarettes in the manufacturing sector. The impact of changes in any or all of these coefficients on the tobacco market can be traced. Similarly, we can study the effect of change in percent of cigarettes filter-tipped, which embodies the changing trend in tastes and habits.

Literature Cited

(1) Durbin, J. and G. S. Watson. "Testing for Serial Correlation in Least Squares Regression. I." Biometrika, Vol. 37, Parts 3 and 4, December 1950.

(2) Goldberger, Arthur S. Econometric Theory. John Wiley and Sons, Inc., New York, 1964.

(3) U.S. Department of Agriculture. Potential Mechanization in the Flue-Cured Tobacco Industry. Agr. Econ. Rpt. No. 169, September 1969.

Footnotes

[1] Italic numbers in parentheses refer to Literature Cited.

[2] This article is a preliminary report of the results of a more comprehensive study of resource adjustment in the U.S. tobacco economy being conducted by an ERS task force.

[3] The burley program is now entirely based on a poundage quota. However, as the poundage quota can be converted to acres by using an appropriate average yield, the present analysis is applicable to the new program.

[4] Although this depends on the distribution of grades of tobacco sold in the auction market, during the period under discussion the average price received by producers for flue-cured and burley was above the average support rate.

[5] The consumer price index includes index numbers for (a) cigarettes, nonfilter tip, regular size, and (b) cigarettes, filter, king. The index for tobacco products includes these two along with other tobacco products. Cigarettes are given a weight of over 90 percent in this index.

[6] To overcome the fact that the data for tobacco are reported by crop year and cigarette consumption and exports are reported by calendar year, the identity (14) was rewritten as

$$QCP_t = QCC_t + QCX_t + QCO_t,$$

where QCO is a residual item which has no operational significance. However, for the sake of completeness, the coefficients for this variable are reported in appendix table 1.

[7] For details, see Goldberger (*2*, p. 375).

[8] This is only one dimension of the problem, since output is measured in terms of land. Another equally important aspect of technological change is output in terms of labor.

Table A-1.–Reduced form of the system

Endogenous variables	Predetermined variables										
	AF_{t-1}	PF_{t-1}	ALF	AB_{t-1}	PB_{t-1}	ALB	SF	SPF	QF	SB	SPB
AF	.08671	3.53768	1.03551								
AB				.14865	.33717	1.01089					
PF	–.00018	–.00737	–.00216				–.00109	1.35435	.26428		
PB				–.00768	–.01742	–.05222				–.02080	.51084
QPF	.16576	6.76288	1.97955								
QPB				.36915	.83730	2.51037					
SF_{t+1}	.16527	6.74281	1.97368	–.00428	–.00972	–.02913	.99703	3.68696	.71945	.01160	.28498
SB_{t+1}	–.00036	–.01472	–.00431	.36600	.83108	2.48901	–.00218	2.70455	.52775	.99149	.20904
DF	.00049	.02007	.00587	.0428	.00972	.02913	.00297	–3.68696	–.71945	.01160	.28498
DB	.00036	.01472	.00431	.00314	.00713	.02137	.00218	–2.70455	–.52775	.00851	–.20904
QC	.00349	.14250	.04171	.03042	.06899	.20684	.02107	–26.18071	–5.10875	.08239	–2.02358
QCC	.00046	.01887	.00552	.00403	.00914	.02739	.00279	–3.46737	–.67660	.01091	–.26800
PC	–.00013	–.00533	–.00156	–.00114	–.00258	–.00774	–.00079	.97994	.19122	–.00308	.07574
QCP	.00046	.01887	.00552	.00403	.00914	.02739	.00279	–3.46737	–.67660	.01091	–.26800
	QB	XF	XB	ODF	ODB	I	QC_{t-1}	FL	QCX	QCO	Constant
AF											–323.18040
AB											–77.00651
PF											–13.84192
PB	.44542										63.88569
QPF											–617.81428
QPB											–191.23258
SF_{t+1}	.24848	–1.00000		–1.00000		–.01013	–.10237	–1.33804	–1.06333	–1.06333	–933.08240
SB_{t+1}	.18227		–1.00000		–1.00000	–.00743	–.07509	–.98151	–.78000	–.78000	–422.49581
DF	–.24848					.01013	.10237	1.33804	1.06333	1.06333	315.26813
DB	–.18227					.00743	.07509	.98151	.78000	.78000	231.26324
QC	–1.76443					.07195	.72692	9.50125			2,238.68415
QCC	–.23368					.00953	.09627	1.25835			296.49133
PC	.06604										39.80130
QCP	–.23368					.00953	.09627	1.25835	1.00000	1.00000	296.49133

Table A-2.—Multiplier effects of a unit change in exogenous variables on endogenous variables in the immediate year

Endogenous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	1.03551												
AB . . .		1.01089											
PF . . .	–.00216		1.35435	.26428									
PB . . .		–.05222			.51084	.44542							
SF . . .	1.97368	–.02913	3.68696	.71945	.28498	.24848	–1.00000		–1.00000		–.01013	–1.33804	–1.06333
SB . . .	–.00431	2.48901	2.70455	.52775	.20904	.18227		–1.00000		–1.00000	–.00743	–.98151	–.78000
QC . . .	.04171	.20684	–26.18071	–5.10875	–2.02358	–1.76443					.07195	9.50125	
QPF . .	1.97955												
QPB . .		2.51037											
DF . . .	.00587	.02913	–3.68696	–.71945	–.28498	–.24848					.01013	1.33804	1.06333
DB . . .	.00431	.02137	–2.70455	–.52775	–.20904	–.18227					.00743	.98151	–.78000
QCC . .	.00552	.02739	–3.46737	–.67660	–.26800	–.23368					.00953	1.25835	
PC . . .	–.00156	–.00774	.97994	.19122	.07574	.06604							
QCP . .	.00552	.02739	–3.46737	–.67660	–.26800	–.23368					.00953	1.25835	1.00000

Table A-3.–Multiplier effects of a unit change in exogenous variables on endogenous variables in the second year

Endogenous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	1.11766		4.79125	.93494									
AB . . .		1.14355			.17224	.15018							
PF . . .	–.00448	.00003	1.34035	.26155	–.00031	–.00027	.00109		.00109		.00001	.00146	.00116
PB . . .	.00009	–.11085	–.05625	–.01098	.49759	.43387		.02080		.02080	.00015	.02042	.01622
SF . . .	4.09385	–.11204	19.14383	3.73561	.76888	.67040	–1.99703	.01160	–1.99703	.01160	–.02751	–3.6336	–2.11445
SB . . .	–.01636	5.26800	7.32402	1.42917	.99172	.86472	.00218	–1.99149	.00218	–1.99149	–.02018	–2.66520	–1.55104
QC . . .	.11657	.58880	–44.71846	–8.72610	–3.43609	–2.99605	–.02107	–.08239	–.02107	–.08239	.12343	16.29883	–.08667
QPF . .	2.13649		9.15930	1.78729									
QPB . .		2.83982			.42773	.37295							
DF . . .	.01642	.08291	–6.29757	–1.22887	–.48390	–.42192	–.00297	–.01160	–.00297	–.01160	.01738	2.29532	1.05112
DB . . .	.01205	.06082	–4.61949	–.90142	–.35495	–.30949	–.00218	–.00851	–.00218	–.00851	.01275	1.68369	.77104
QCC . .	.01543	.07797	–5.92243	–1.15567	–.45507	–.39679	–.00279	–.01091	–.00279	–.01091	.01635	2.15859	–.01148
PC . . .	–.00323	–.01640	.96148	.18762	.07355	.06413	.00079	.00308	.00079	.00308	.00003	.00408	.00324
QCP . .	.01543	.07797	–5.92243	–1.15567	–.45507	–.39679	–.00279	–.01091	–.00279	–.01091	.01635	2.15859	.98852

Table A-4.—Multiplier effects of a unit change in exogenous variables on endogenous variables in the third year

Endogenous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	1.11656	.00011	5.15717	1.00634	–.00110	–.00096	.00386		.00386		.00004	.00516	.00410
AB . . .	.00003	1.14350	–.01897	–.00370	.19338	.16861		.00701		.00701	.00005	.00688	.00547
PF . . .	–.00679	.00012	1.32274	.25811	–.00084	–.00073	.00217	–.00001	.00217	–.00001	.00003	.00395	.00230
PB . . .	.00034	–.16865	–.15136	–.02954	.48022	.41872	–.00005	.04106	–.00005	.04106	.00042	.05508	.03198
SF . . .	6.19812	–.26582	37.09689	7.23887	1.38415	1.20688	–2.98162	.04290	–2.98162	.04290	–.04989	–6.58856	–3.13698
SB . . .	–.03847	7.99473	13.21426	2.57855	1.92480	1.67830	.00808	–2.95111	.00808	–2.95111	–.03652	–4.82306	–2.29327
QC . . .	.21462	1.09366	–57.47679	–11.21569	–4.38391	–3.82248	–.05706	–.22229	–.05706	–.22229	.15944	21.05466	–.23406
QPF . .	2.13440	.00021	9.85838	1.92371	–.00210	–.00183	.00737		.00737		.00007	.00986	.00784
QPB . .	.00008	2.83970	–.04710	–.00919	.48022	.41872		.01742		.01742	.00013	.01709	.01358
DF . . .	.03023	.15400	–8.09427	–1.57947	–.61738	–.53831	–.00804	–.03130	–.00804	–.03130	.02245	2.96507	1.03037
DB . . .	.02219	.11297	–5.93734	–1.15858	–.45286	–.39486	–.00590	–.02296	–.00590	–.02296	.01647	2.17495	.75582
QCC . .	.02842	.14483	–7.61211	–1.48538	–.58059	–.50624	–.00756	–.02944	–.00756	–.02944	.02112	2.78844	–.03099
PC . . .	–.00487	–.02489	.93464	.18238	.07060	.06156	.00157	.00607	.00157	.00607	.00008	.01102	.00640
QCP . .	.02842	.14483	–7.61211	–1.48538	–.58059	–.50624	–.00756	–.02944	–.00756	–.02944	.02112	2.78844	.96901

Table A-5.—Multiplier effects of a unit change in exogenous variables on endogenous variables in the fourth year

Endogenous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	1.10830	.00044	5.12661	1.00038	–.00305	–.00266	.00801	–.00004	.00801	–.00004	.00011	.01442	.00848
AB . . .	.00012	1.12401	–.05385	–.01051	.19066	.16624	–.00002	.01489	–.00002	.01489	.00015	.01959	.01160
PF . . .	–.00907	.00029	1.30324	.25431	–.00150	–.00131	.00323	–.00005	.00323	–.00005	.00005	.00715	.00340
PB . . .	.00079	–.22435	–.27207	–.05309	.46095	.40192	–.00017	.06061	–.00017	.06061	.00075	.09931	.04710
SF . . .	8.27060	–.50128	56.17711	10.96207	2.08016	1.81375	–3.95175	.09925	–3.95175	.09925	–.07556	–9.97953	–4.12460
SB . . .	–.07209	10.61267	19.88748	3.88073	2.91308	2.54002	.01873	–3.87274	.01873	–3.87274	–.05513	–7.28196	–3.00083
QC . . .	.32810	1.67810	–65.89587	–12.85854	–4.98369	–4.34545	–.10331	–.40078	–.10331	–.40078	.18383	24.27469	–.42247
QPF . .	2.11861	.00084	9.79993	1.91230	–.00583	–.00509	.01531	–.00009	.01531	–.00009	.00021	.02757	.01621
QBF . .	.00029	2.79129	–.13374	–.02610	.47347	.41284	–.00004	.03697	–.00004	.03697	.00037	.04866	.02880
DF . . .	.04622	.23629	–9.27987	–1.81082	–.70184	–.61196	–.01456	–.05643	–.01456	–.05643	.02589	3.41854	1.00383
DB . . .	.03391	.17334	–6.80697	–1.32827	–.51481	–.44888	–.01068	–.04140	–.01068	–.04140	.01899	2.50757	.73635
QCC . .	.04344	.22223	–8.72712	–1.70296	–.66002	–.57550	–.01368	–.05307	–.01368	–.05307	.02435	3.21489	–.05595
PC . . .	–.00645	–.03302	.90262	.17613	.06726	.05865	.00232	.00894	.00232	.00894	.00015	.01989	.00944
QCP . .	.04344	.22223	–8.72712	–1.70296	–.66002	–.57550	–.01368	–.05307	–.01368	–.05307	.02435	3.21489	.94405

Table A-6.–Multiplier effects of a unit change in exogenous variables on endogenous variables in the fifth year

Endo-genous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	1.09953	.00106	5.05496	.98640	–.00558	–.00486	.01213	–.00017	.01213	–.00017	.00020	.02655	.01277
AB . . .	.00029	1.10233	–.09974	–.01946	.18376	.16023	–.00006	.02265	–.00006	.02265	.00028	.03640	.01760
PF . . .	–.01131	.00054	1.28259	.25028	–.00226	–.00197	.00428	–.00011	.00428	–.00011	.00008	.01082	.00447
PB . . .	.00148	–.27769	–.40851	–.07971	.44075	.38431	–.00039	.07938	–.00039	.07938	.00113	.14958	.06151
SF . . .	10.30898	–.82442	75.84984	14.80090	2.81942	2.45833	–4.90653	.18393	–4.90653	.18393	–.10327	–13.63890	–5.07378
SB . . .	–.11802	13.11157	26.98183	5.26507	3.91950	3.41756	.03474	–4.75414	.03474	–4.75414	–.07506	–9.91302	–3.67128
QC . . .	.45117	2.30925	–71.07632	–13.86943	–5.32511	–4.64315	–.15635	–.60369	–.15635	–60369	.19951	26.34528	–.63713
QPF . .	2.10184	.00203	9.66296	1.88557	–.01067	–.00930	.02319	–.00032	.02319	–.00032	.00038	.05075	.02441
QPB . .	.00071	2.73744	–0.24769	–.04833	.45634	.39790	–.00015	.05625	–.00015	.05625	.00068	.09038	.04372
DF . . .	.06355	.032517	–10.00938	–1.95317	–.74993	–.65388	–.02203	–.08501	–.02203	–.08501	.02809	3.71013	.97360
DB . . .	.04664	.23853	–7.34204	–1.43268	–.55008	–.47963	–.01616	–.06236	–.01616	–.06236	.02061	2.72145	.71417
QCC . .	.05974	.30581	–9.41321	–1.83683	–.70524	–.61493	–.02070	–.07994	–.02070	–.07994	.02642	3.48911	–.08437
PC . . .	–.00797	–.04074	.86746	.16927	.06373	.05556	.00305	.01168	.00305	.01168	.00023	.02999	.01235
QCP . .	.05974	.30581	–9.41321	–1.83683	–.70524	–.61493	–.02070	–.07994	–.02070	–.07994	.02642	3.49811	.91563

Table A-7.—Long-run equilibrium effects of a unit change in exogenous variables on endogenous variables

Endogenous variables	Exogenous variables												
	ALF	*ALB*	*SPF*	*QF*	*SPB*	*QB*	*XF*	*XB*	*ODF*	*ODB*	*I*	*FL*	*QCX*
AF . . .	.39445	.82783	–.00007	–.00001	–.00003	–.00002	.34112	–.28075	.34112	–.28075	.00502	.66238	.14374
AB . . .	.22282	.46737	.00065	.00013			–.10280	.24418	–.10280	.24418	.00283	.37392	.08115
PF . . .	–.19088	.21371	–.00002		–.00001	–.00001	.08806	–.07248	.08806	–.07248	.00129	.17100	.03711
PB . . .	.56261	–1.81805	.00164	.00032	–.00001	–.00001	–.25957	.61656	–.25957	.61656	.00715	.94414	.20491
SF . . .	174.36091	–197.64935	1242.53874	242.46153	.00605	.00485	–81.44377	67.02940	–81.44377	67.02940	–1.19756	–158.14641	–34.31867
SB . . .	–27.60224	86.24553	–.08042	–.01568	24.56003	21.41484	12.73474	–30.24881	12.73474	–30.24881	–.35072	–46.31999	–10.05284
QC . . .	5.35050	11.24312	–.02532	–.00494	.00017	.00014	–2.46851	–3.81292	–2.46851	–3.81292	.06812	8.99367	–5.59892
QPF . .	.75402	1.58247	–.00013	–.00002	–.00005	–.00004	.65207	–.53667	.65207	–.53667	.00959	1.26619	.27477
QPB . .	.55333	1.16065	.00161	.00031	–.00001	–.00001	–.25529	.60639	–.25529	.60639	.00703	.92856	.20153
DF . . .	.75405	1.58254	–.00013	–.00002	–.00005	–.00004	–.34789	–.53669	–.34789	–.53669	.00959	1.26625	.27478
DB . . .	.55333	1.16064	.00161	.00031	–.00001	–.00001	–.25529	–.39361	–.25529	–.39361	.00703	.92856	.20153
QCC . .	.70856	1.48894	–.00398	–.00078	–.00002	–.00002	–.32690	–.50495	–.32690	–.50495	.00902	1.19126	–.74147
PC . . .	–.05503	–.11432	–.00142	–.00028	.00009	.00008	.02539	.03877	.02539	.03877	.00200	.26374	.05724
QCP . .	.70856	1.48894	–.00398	–.00078	–.00002	–.00002	–.32690	–.50495	–.32690	–.50495	.00902	1.19126	.25853

BOOK REVIEWS

Agricultural Product Prices

By William G. Tomek and Kenneth L. Robinson. Cornell University Press, 124 Roberts Place, Ithaca, N.Y. 14850. 376 pages. 1972. $14.50.

According to the preface: "The decision to write this book was motivated by two considerations. First, we believe that the behavior of agricultural product prices is sufficiently unusual as to require special treatment. Second, we saw a need for a more up-to-date text, which would combine principles of price determination, information on pricing institutions, and an introduction to selected quantitative techniques as applied to agricultural prices" (p. v).

Textbooks—this one for "an intermediate-level course in agricultural prices and marketing"—are not usually reviewed in this journal. However, I think a review is justified in this instance. The book is designed to develop research competence in statistical price analysis of agricultural products, and draws heavily on published research, notably articles in the Journal of Farm Economics (now the American Journal of Agricultural Economics) and USDA studies, including several from this journal.

The 16 chapters are grouped into four sections. "The first . . . is devoted to a review of the economic concepts that underlie price determination, particularly as they apply to agricultural commodities. This is followed by a section dealing with price variation and the linkage between prices at the retail, wholesale, and farm levels, at different points in time, and in different locations. The third section is devoted to a description and analysis of alternative pricing arrangements for agricultural commodities, such as commodity exchanges, auctions, pricing formulas, collective bargaining, and government-support programs. The final section provides an introduction to analytical methods and empirical studies of demand and supply relationships for agricultural commodities" (pp. 5-6).

Tomek and Robinson have produced a volume that reflects their recognized competence in economic and statistical analysis. It is well-written, well-organized, and comprehensive, though the last two attributes are more evident in sections I-III, which comprise the bulk of the book, than in section IV.

In the first section, I regard the chapters on demand (ch. 1, 2) as particularly outstanding. The summary of demand theory and the discussion of interrelationships among various elasticities and related concepts, such as price flexibility, provide a solid introduction to the whole area of price determination.

In section II, the disparate forces that determine the prices of farm products are organized into a coherent pattern. I think the authors were particularly successful in bringing recent research results to bear on the problems of marketing margins (ch. 6) and cyclical price variations (ch. 9), where the venerable cobweb theory receives special emphasis.

In section III, the treatment of commodity futures (ch. 12, 13) is most welcome. Conventional textbook presentations are often superficial, and sometimes seem designed to confuse students and teachers alike. The present authors have drawn on numerous empirical studies made during the last decade or so. In so doing they have brought out the important differences between futures markets—with respect to both function and price behavior—for seasonally produced, highly storable commodities; and those produced more continuously, with stock accumulation relatively small or nonexistent.

I have very few reservations with respect to this generally excellent book. As noted above, one of its features is comprehensiveness. However, the value of this attribute is somewhat reduced by attempting to cover an unusually large number of highly technical topics in only 375 pages. As a result, the treatment of some subjects tends to be a bit sketchy or overconcise.

One example is the section, "Effects of Inflation and Deflation on Agriculture" (ch. 10, pp. 201-203). Here the relation between general price inflation and farm price inflation; "demand-pull" versus "cost-push" inflation; and the interconnections of domestic inflation, export markets, and currency devaluation are squeezed into two and a half pages.

It also appears to me that the distinction between demand-pull inflation which tends to benefit farmers, and cost-push inflation which tends to hurt them, is drawn too sharply. The even more important situation, where it is Government policy to offset the adverse effects of large wage-price increases on employment by measures to expand aggregate demand—thereby

engendering another cost-push round—is not mentioned. The authors evidently did not think it of sufficient importance to be included at the time of writing. This is understandable as, through 1971, the cost-push element appears to have been strong enough to prevent gains in net farm income. Since 1972, however, the demand-pull forces that have been superimposed on the cost-push forces have brought large gains to farmers.

The two chapters (15, 16) in section IV provide a second example of highly compressed treatment. The first of these is "devoted to a discussion of alternative techniques of analysis, procedures in formulating models, sources of data, and the identification problem" (p. 308). The second "provides a basis for interpreting and using the results of price analysis based on regression techniques" (p. 338). These chapters are rather different from the preceding ones, as they are designed "not to give a rigorous statistical treatment, but to provide an intuitive review and some insights into uses and appraisal of quantitative economic analyses" (ibid.). I would regard them as a teaching syllabus that will allow instructors a large degree of flexibility as to topics covered and the level of instruction, which will depend on the extent and depth of the introductory courses in statistics that the students are supposed to have had.

It would almost seem that the authors themselves are not quite certain as to just what the scope and content of section IV should be, and perhaps look forward to future revisions on the basis of actual experience with the use of this book as a manual of instruction. My own opinion is that this section will need to be revised and expanded quite substantially. I offer only one suggestion. I think it would be most useful to take a number of specific studies, such as the supply analysis for corn by Houck and Ryan (Amer. Jour. Agr. Econ. 54: 184-191) and make a step-by-step critique of the formulation of the model, the choice of variables and statistical series, and the significance of such measures as the R^2 and the *t*-values of the regression coefficients. Then, when appropriate, the equations should be tested as forecasting devices; and if they don't work as well as hoped, the whole analysis should be carefully reexamined to find out why.

The foregoing reservations notwithstanding, this is a book of very high quality. It is also a much needed one that deserves to be widely used. Finally, I note that it is singularly free of printing errors. The only one I noticed is on page 351, where "first different equation" should read "first difference."

James P. Cavin

Size, Structure and Future of Farms

Edited by A. Gordon Ball and Earl O. Heady. The Iowa State University Press, Ames 50010. 404 pages. 1972. $9.95.

This is the most comprehensive collection of essays on U.S. agriculture that this reviewer knows about. The book appears at a time when public interest in agriculture is growing, as evidenced by the popular media's devotion to the subject of higher food prices, and has the added virtue of being timely for the layman as well as for economists who have a day-to-day responsibility for the problems of farms.

Several of the essays seek to clarify the distinction between advantages accruing to a farm enterprise because of size and those accruing because of its organization, specifically whether it is incorporated or vertically integrated. Ball and Heady in "Trends in Farms and Enterprise Size and Scale" give a factual interpretation of the available data on scale and efficiency criteria. They surmise:

> A family farm under a single proprietor can get as big as any corporate farm, given the same opportunities for acquisition of credit, profits, equal tax benefits, legal protection, and intergenerational continuity. But these opportunities are not as equal for all sizes and incomes under the single entrepreneurship as they are under the corporate form of farm business organization.

In a corollary essay, Madden and Partenheimer in "Evidence of Economies and Diseconomies of Farm Size" explore the relationship between scale of operation and likelihood of financial success. Specifically, they analyze the efficiencies of financial management as those considerations affect production coordination and the use of available information to reduce the uncertainty of the production decisions.

These essays are complemented by other, equally well-written studies of related issues. For instance, Daly, Dempsey, and Cobb coauthor an essay, "Farm Numbers and Sizes in the Future," which projects the profile of today's farm sector forward to 1980; the glimpse of the future they offer can "flex the mind of the most imaginative futurist," in the words of the authors.

The dominant theme throughout the book is best characterized by Heady and Ball in their second essay, "Public Policy Means and Alternatives," in which they argue that past and present farm policies are strong forces working in a manner which gives profit and payment incentives primarily to large scale enterprises. As economic efficiency and social justice are mutually exclusive alternatives in the eyes of many who study the

agricultural sector of the U.S. economy, this theme should be of special interest to those who are instrumental in forming or advising on farm policy.

The structure of agricultural production is in a state of flux. New patterns—vertical integration, contract farming, and increasingly rapid introduction of new technology—are emerging. Agricultural policy will affect the impact of these new patterns on the whole social spectrum from producer to consumer and will be a major force in maintaining or changing agriculture's structure. Future farm programs should be formulated with the awareness that the choice of a particular policy is the conscious choice of a particular structure of agriculture.

A recurrent theme throughout all the essays is that past choices have aided big farms, and to choose a different structure, we must choose different policy. Aines, in "Linkages in Control and Management with Agribusiness," discusses corporations establishing ties in control and management with American agriculture. More and Dean in "Industrialized Farming" discuss managerial functions and the availability of information as both apply to small and large farms. Fuller and Van Vuuren in "Farm Labor and Labor Markets" discuss the linkages between agriculture and the rest of the economy, concluding that the allocation of human resources will be affected by Government policy in much the same way as the allocation of physical resources. Raup, in the introductory essay, "Societal Goals in Farm Size," states that "society's interest in the size-of-farm question has less to do with costs of production or allocative efficiency and more to do with intangible values, including distributive equity, community structure, population distribution, and rural amenities."

A. Gordon Ball and Earl O. Heady present this collection so that we may decide more rationally if the sacrifice of intangible values is justified by increasing efficiency. Space does not allow discussion of each essay, but I hope the reader will find that the favorable opinion expressed for the essays collectively is applicable individually.

David Dyer

World Without Borders

By Lester R. Brown. Random House, 201 East 50th Street, New York, N.Y. 10022. 395 pages. 1972. $7.95.

If one examines the dynamics of our world society with any degree of insight, one is easily led to conclude that global economic and political integration would be beneficial. The author not only argues that "One World" would be an ideal but insists that unless it is achieved in the near future, disaster will result. Lester Brown is a senior fellow at the Overseas Development Council of Washington, D.C., and has a national reputation in economics. To him, global unity is not an impossible undertaking because the means to bring it about are available: It would necessitate only some radical changes in thinking and traditions. In this respect the author appears somewhat quixotic, since history shows that such changes have occurred exceedingly slowly.

What is essentially needed to carry out a change, the author asserts, is a transformation of those values which up to now we have considered to be gospel: Growth is good, planned obsolescence, reverence for large families. Ironically these values have brought chaos and pollution to our society and therefore must be discarded. What must evolve is a new social ethic, one which emphasizes stability. Such an ethic should replace international competition with global cooperation and bring mankind in harmony with nature.

National sovereignty is being gradually sacrificed for affluence. Is this good or bad? On the one hand, the author is somewhat critical of Americans for their affluence, asking them to question their right to consume a third of the earth's resources. On the other hand he points out that when economic integration occurs, political cooperation gradually follows, coupled with an enhanced standard of material living, citing the European Economic Community as an example. He predicts that there will be a rise of the "data utility industry," as information will become a major economic resource. (Some multinational corporations have economies larger than countries.) Hereafter the number of computers in a country rather than automobile production will be the measure of progress and level of development.

The author explores the reason why the Soviet Union can master space exploration but cannot give its citizens the consumer goods they want to buy. Why is it that a centrally planned economy which is efficient in steel production cannot keep up with the latest fashions? This is a critical flaw in a planned society. A country's economy must be sensitive to consumer desire and be service-minded as well as production oriented. As the planned economies approach advanced stages of industrialization, they discover they lack the skills and technology needed to create a modern consumer society. The only way to get the needed technology quickly is to turn to the West for it.

Jack Ben-Rubin

Land Speculation, An Evaluation and Analysis

By Harold L. Oppenheimer. The Interstate Printers and Publishers, Inc., Danville, Ill. 61832. 439 pages. 1972. $9.95.

This is rather an unusual book to recommend for a researcher's shelf. Although it reads more like a prospectus than a treatise, it provides a point of view not always open to, nor understood by, the researchers in agricultural economics. *Land Speculation* is not research in the academic sense, nor does it present a well developed thesis or conclusion. Oppenheimer, the chairman of a ranch managing and consulting firm, builds a case for livestock production as a safe tax haven for upper income taxpayers. To do this he uses a collection of magazine articles, congressional testimony, ranch history, tax cases, and management advice.

The other side of this coin, of course, involves the economic impact of the additional capital introduced into livestock production. Will it raise or lower production costs? Will it raise or lower meat prices? This issue is dealt with in testimony before a congressional committee. Outside investment may replace a certain amount of more expensive loan capital, which means tougher competition for those left paying the higher interest rates. It will strengthen the demand for ranchland, help to preserve existing large holdings, and consolidate uneconomic operations. Some ranchers may benefit, others may lose, from this competition. The consumer should gain.

Oppenheimer is not talking to or about dabblers or speculators. He advocates business deals involving both legitimate livestock men and city investors. Partnership arrangements can increase available equity capital to expand their scale of operations to an efficient level of at least 1,000 head. His advocacy is based on thorough knowledge from many years of experience. In the process of presenting his credentials to prospective clients, he unfolds the kind of analysis that typically begins on the back of an envelope and sometimes leads to a trip to the bank. He compares this business with other speculative land deals such as urban income property and rural subdivisions.

A rapid perusal of this book will give new perspectives to some of the economic forces shaping land use in this decade. Serious analysis of some sections regarding the impact of taxes on investment and resource use is warranted. Land use decisions can be quite sensitive to tax laws. The influence of Federal policy on private land use decisions is felt in large measure through the income tax laws. There is a question whether current proposals for more direct regulation of land use will have the desired effect without taking the tax effect into account. Thus, Oppenheimer adds the third dimension to costs and returns in the livestock industry—taxes.

Howard A. Osborn

Praeger Library of U.S. Government Departments and Agencies, Praeger Publishers, Inc., 111 Fourth Avenue, New York 10003:

The Bureau of Reclamation

By William E. Warne. 270 pages. 1973. $9.50.

The Forest Service

By Michael Frome. 241 pages. 1971. $8.75.

The National Park Service

By William C. Everhart. 275 pages. 1972. $9.

The historical development of these three agencies has become of increasing interest with the growing concern about our environment and conservation of natural resources. Each has had its goals, that have shifted as years have passed. At times, the goals of these bureaus have been in direct conflict. The approach to the task of writing the books has varied from one author to another. Warne is a former Commissioner of the Bureau of Reclamation; Everhart is the Director of the National Park Service Harpers Ferry Center; Frome is the conservation editor of *Field and Stream*, and a contributor to *American Forests*, *Holiday*, and other magazines. He has written other books on the national forests of America. Everhart's account gives many human interest details that would only come from long association with the National Park Service and that make reading his story most enjoyable.

Of the three agencies, formal roots of the National Park Service go the farthest back—to the establishment of Yellowstone National Park in 1872. No funds were available for administration of the park until 1886 when, at the request of the Secretary of the Interior, the War Department took over control of the park—an arrangement that was to continue for 30 years. In 1890, Sequoia, Yosemite, and General Grant National Parks were created. In 1891, Congress authorized the President to establish forest reserves from the public domain. The

forest reserves, subsequently redesignated national forests, developed into a system parallel to the national parks system. In 1905, these reserves were transferred from the jurisdiction of the Department of the Interior to the Department of Agriculture, where they were combined with other forestry activities under Gifford Pinchot in the Forest Service.

The Antiquities Act, enacted in 1906, empowered the President to designate as national monuments any lands owned or acquired by the Federal Government containing historic landmarks, historic or prehistoric structures, and other objects of historic or scientific interest. Administration of the monuments was left to the department having jurisdiction over the land. But still there was no centralized administration for the Nation's parks until the National Park Service was established by an Act of Congress in 1916—

> To conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

Another turning point in the growth of the National Park Service occurred in 1933, when nearly 50 historic sites were transferred to the Service, primarily from the War Department. Thus was recognition given to its capability of operating all Federal parks. The New Deal period brought new directions. The Civilian Conservation Corps conducted many work projects. Parkways, recreation areas, and seashores and lakeshores came under the jurisdiction of the Service.

In 1956, another milestone was reached when Mission 66 was undertaken to rejuvenate the parks and their facilities. Legislation in the 1960's, such as the Land and Water Conservation Fund and the Wilderness Act of 1964, the Historic Preservation Act of 1966, and the Wild and Scenic Rivers Act of 1968, added significantly to the responsibilities of the agency. Following the establishment of an Office of Urban Affairs, the "Summer in the Parks" program in Washington, D.C., has added dimension.

As the work of the National Park Service has increased one of the basic questions has been whether to emphasize preservation or use. Ideologies of other agencies have presented challenges to the position of the Park Service.

Through the years, a number of Secretaries of the Interior have eyed the Forest Service and worked to have it transferred to their jurisdiction. Conversely, Secretaries of Agriculture have, with decreasing interest, held on to it. The current President's Reorganization Plan would transfer the Forest Service, the National Park Service, and the Bureau of Reclamation, as well as related activities of the Corps of Engineers from the Department of Defense, to a new Department of Natural Resources.

Work in forestry predated the establishment of the first of the national forest reserves, Yellowstone Timberland Reserve in 1891, under the jurisdiction of the Secretary of the Interior. Extensive reports had been made on forest resources and given wide circulation. Bernhard Fernow, the first professional forester, was adding research in silviculture and wood. Under Gifford Pinchot, forestry activities included assistance in solving problems of those outside the Government and the administration of the forest reserves under the Interior Department.

A basic element in the administration of the reserves that were redesignated national forests was conservation under the guidance of the Federal Government. It is at this point that Frome criticizes the Forest Service as it operates today. He objects especially to the dominant use theory and to clearcutting, stressing complex effects on resources and the environment.

The third of these studies, *The Bureau of Reclamation* by William Warne, discusses the efforts of the Federal Government to provide water to the area west of the 100th meridian. To this was added the generation of power from the vast resources behind its huge dams. In the about 70 years of its history the Bureau has had problems as it has built its vast network of dams, hydroelectric plants, and related projects. There has been the question of extensive versus intensive farming; conservationists have fought inundation of land; other Government agencies have resisted what they considered encroachments on their sphere of activities.

The three studies illustrate the complexity of Government activities and the pressures that have been and are exerted in our increasingly developed Nation. They also show how at times a program of one agency can drastically affect another's jurisdiction. And, of course, all three agencies have tremendous social and economic impacts on the public, and on mining, lumber, and related industries.

There are a few problems in using these studies. One must read all three to acquire an overall view. Then it would be well to consult related studies in the Praeger series, such as *The Soil Conservation Service*, *The Bureau of Land Management*, and *The United States Department of Agriculture*. There are some scattered factual errors in all and some omission of information on related activities prior to the establishment of the Bureau of Reclamation. Moreover, appendix B in the Frome study, "Major

Laws Relating to Forest Service Activities," does not give an exact reproduction of the laws as enacted.

Setting aside these problems, all three books present the current activities of the agencies in a clear perspective. One realizes something of the impact across the country of these three bureaus.

Vivian Wiser

U. S. GOVERNMENT PRINTING OFFICE : 1973 O - 509-051

Suggestions for Submitting Manuscripts for Agricultural Economics Research

Each contributor can expedite reviewing and printing his paper by doing these things:

1. SOURCE. Indicate in a memorandum how the material submitted is related to the economic research program of the U.S. Department of Agriculture and its cooperating agencies. State your own connection with the program.
2. CLEARANCE. Obtain any approval required in your own agency before sending your manuscript to one of the editors or assistant editors of Agricultural Economics Research.
3. ABSTRACT. Include an abstract when you submit your article. The abstract should not exceed 100 words.
4. NUMBER OF COPIES. Submit one ribbon copy and two additional good copies of the article for review.
5. TYPING. Double space everything, including abstract and footnotes.
6. FOOTNOTES. Number consecutively throughout the paper.
7. REFERENCES. Check all references carefully for accuracy and completeness.
8. CHARTS. Use charts sparingly for best effect. Include with each chart a page giving essential data for replotting.
9. FINAL TYPING. Manuscripts accepted for publication will be edited and returned to author with instructions for retyping if necessary.

AGER HOLE 453E R 1
ERLING HOLE
6453 OAKWOOD DR
FALLS CHURCH VA 22041

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF
AGRICULTURE
FIRST CLASS
AGR 101

U.S.MAIL

AGRICULTURAL ECONOMICS
RESEARCH

Is published quarterly by the Economic Research Service, U.S. Department of Agriculture. Use of funds for printing this publication approved by the Director of the Office of Management and Budget, February 12, 1970.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 65 cents a single copy, $2.00 a year domestic, $2.50 foreign.